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PROCEDURE FOR CONDITION SURVEY OF CIVIL AIRPORTS.(U)
MAY 80 J W HALL, D R ELSEA DOT-FA78WAI-846
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PROCEDURE FOR CONDITION SURVEY OF CIVIL AIRPORTS

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Procedure Recommended in this Report Developed by
Dr. M. Y. Shahin et al.
Construction Engineering Research Laboratory

MAY 1980
FINAL REPORT

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16. Abstract

With an increase in air traffic and relatively limited new airport pavement construction, a major effort is being devoted to strengthening, rehabilitating, and maintaining existing pavements with emphasis on improved safety and increased capacity. This study was undertaken to provide airport pavement engineers with techniques for assessing the present condition of an airport pavement, for making comparisons of design predictions to actual performance, and for making predictions as to the remaining life of a pavement.

A review of existing techniques for surface condition evaluation was made, and the best features of each procedure were extracted for the development of the proposed FAA procedure. The basis of this procedure is taken from work done by the U. S. Army Construction Engineering Research Laboratory (CERL), and the condition rating procedure developed by CERL for the Air Force was rated as the most comprehensive method reviewed and was selected as the method with the most potential for use on civil airports.

Appendix A presents the condition survey procedure, and Appendix B presents an airport pavement distress identification manual.

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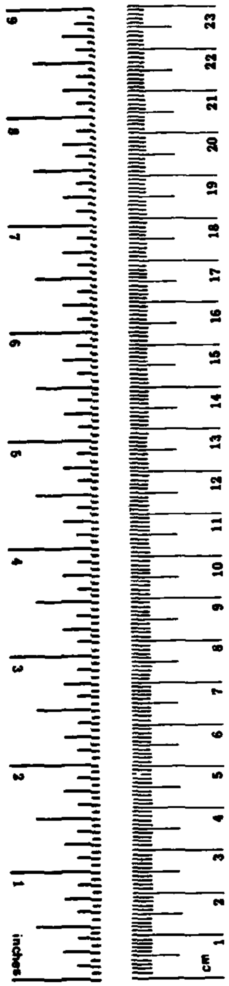
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

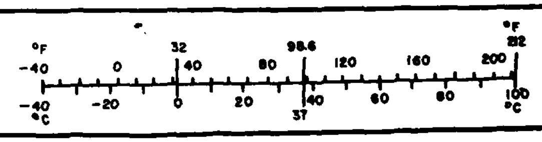
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



ACKNOWLEDGEMENT

The pavement condition rating procedure recommended in this report was developed by the U. S. Army Construction Engineering Research Laboratory (CERL) for the Civil and Environmental Engineering Development Office (CEEDO), Air Force Systems Command, Tyndall Air Force Base, Florida.

Personnel directly responsible for the development of the Air Force procedure were Dr. Mohamed Y. Shahin of CERL and Mr. D. N. Brown of CEEDO.

PREFACE

The study described in this report was sponsored by the Federal Aviation Administration under Inter-Agency Agreement No. DOT-FA78-WAI-846, "Airport Pavement Performance Analysis." Work was initiated on the project in January 1978.

The study was conducted under the general supervision of Mr. J. P. Sale, Chief, Geotechnical Laboratory (GL), and Mr. A. H. Joseph, Chief, Pavement Investigations Division, GL, of the U. S. Army Engineer Waterways Experiment Station (WES). This report was prepared by Messrs. J. W. Hall, Jr., and D. R. Elsea.

COL John L. Cannon, CE, and COL Nelson P. Conover, CE, were Commanders and Directors of WES during the conduct of this study and preparation of this report. Mr. Fred R. Brown was Technical Director.

CONTENTS

INTRODUCTION

BACKGROUND

The majority of airport pavements in use today were constructed a number of years ago. Many of these pavements, particularly those subjected to traffic in excess of design levels, are now exhibiting signs of distress. New pavements being constructed today will begin gradual deterioration due to repeated load stresses and environmental effects. Airport pavement engineers need techniques for assessing the present condition of a pavement, for making comparisons of design predictions to actual performance, and for making predictions as to the remaining life of a pavement. Although air traffic is on the increase, not many new airports are being constructed. Existing airports are being expanded through new pavement construction, but the major effort is being devoted to strengthening, rehabilitating, and maintaining existing pavements with emphasis on improved safety and increased capacity.

PURPOSE

The specific purpose of this study was to develop within the current state of the art a system of condition data collection for civil airport pavements. This condition survey procedure will provide the Federal Aviation Administration (FAA), airport owners, and consulting engineers with a uniform surface condition rating system and will serve as a method of feedback to the FAA for comparison of actual pavement performance to predicted performance by design and evaluation methods. This will be of special importance in the checking and verification of new design theories and specifications for new materials, stabilization processes, recycled pavement performance, etc.

SCOPE

The scope of the project was limited to those techniques available from the present state of the art. A review of existing techniques for surface condition evaluation was made, and the best features of each procedure were extracted for the development of the proposed FAA

procedure. The basis of the FAA procedure is taken primarily from work done by the U. S. Army Construction Engineering Research Laboratory (CERL). The procedure given herein for pavement condition survey is designed primarily for use by airport owners/operators and consulting airport engineers.

REVIEW OF EXISTING PROCEDURES

A review was made of several existing condition survey rating procedures. A summary of important aspects of each is given here.

CORPS OF ENGINEERS/AIR FORCE

The condition survey procedure used for many years on Air Force and Army airfield pavements consisted principally of a visual inspection of the pavement surfaces for signs of pavement distress resulting from the influence of aircraft traffic. (A new procedure developed for Air Force pavements is described under the CERL procedure.) The procedures are described in Technical Manuals TM 5-827-2/AFM 88-24[1] and TM 5-827-3/AFM 88-24[2] and Air Force Regulation 93-5.[3] The purposes of the condition survey were to establish the existing condition of the pavement, to determine the performance of pavements under load, and to aid in programming airfield maintenance. The procedures for flexible and rigid pavements are somewhat different, but certain basic information is collected regardless of pavement type. This information includes construction history, traffic history, weather and precipitation data, plans and cross sections, drainage features, grades, frost action, joint types and conditions, and photographs. The procedures are:

a. Rigid pavement. Condition surveys on rigid pavement involve identification of distress types in each slab of the pavement feature. A grid numbering system is established by which every slab in the pavement feature can be located. Any one or a number of defects may be recorded for any one slab. The survey data are used to compute the "percentage of slabs, no defects" and the "percentage of slabs, no major defects." These values are then used to rate the pavement condition based on the following:

Percent Slabs, No Defects		Percent Slabs, No Major Defects		Condition
K = 25 to 200	K > 200	K = 25 to 200	K > 200	
90-100	80-100	98-100	90-100	Excellent
80-98	70-90	90-98	80-90	Very Good
70-90	60-80	80-90	70-80	Good
60-80	50-70	70-80	60-70	Fair
<60	<50	<70	<60	Poor

It is pointed out in the procedure that the condition of the pavement can only be determined by "visual examination, overall analysis of the results of the survey, and applied engineering judgement."

b. Flexible pavement. The condition survey accomplished on flexible airfield pavements consists essentially of a visual inspection of the pavements for evidence of distress. Satisfactory pavements are noted as to color, texture, smoothness, etc., and are not studied in any great detail. Emphasis is placed on failed pavements, particularly as to the cause of failure. Condition surveys of failed pavements may result in field and/or laboratory tests to evaluate the cause of failure. Types of distress such as shear failure (plastic flow), "map" cracking, rutting, densification and upheaval, shrinkage cracking, fuel spillage damage, and jet blast damage are defined in general terms. Subjective ratings are given based on the visual inspection with the following ratings:

(1) Excellent. Denotes pavement that has no noticeable deformation or failure and with zero to few longitudinal, transverse, and shrinkage cracks. All defects are being properly maintained.

(2) Good. Denotes pavement in average condition that exhibits no noticeable deformation or failure but contains a limited amount of cracking. Cracks are not maintained to a standard that produces a completely watertight surface.

(3) Fair. Denotes pavement with transverse and longitudinal cracking and minor defects such as oxidized surface, random cracking, and minor deformation or rutting.

(4) Poor. Denotes pavement with major deformation or failure that limits the structural capacity of the pavement.

Condition survey reports prepared by the Corps of Engineers contain such information as a general description of the airfield, a history of pavement construction, a traffic history including aircraft types and number of operations, a list of maintenance performed on the pavements, and a narrative description of the pavement condition.

NAVY CONDITION RATING

The Navy,[4,5] in order to improve the subjective rating system, devised a rating system based on the measurement of pavement defects and a severity weighting of each defect. The steps of the Navy procedure are (a) a preliminary survey, (b) a statistical sampling and defect

survey, (c) a defect severity weighting system, and (d) a facility summary--weighted defect densities. The preliminary survey consists of a general inspection of all pavements and a division of the pavements into "discrete areas" based on the construction history and defect distribution. A discrete area may vary from a 500-ft* length of runway or taxiway to the entire length of the facility. During the preliminary survey, attention is given to special singular occurrences of serious defects that might be overlooked in the statistical sampling procedure. The second step is to divide the discrete pavement areas into small "sample areas." A sample area in portland cement concrete (PCC) pavements may be a single slab or a number of adjacent slabs. For asphaltic concrete (AC) pavements, samples are 50-sq-ft. The sample areas are selected within the center 100 ft of runways and the center 50 ft of taxiways. No measurement of length, area, etc., is recorded for PCC pavement defects, but for AC pavements the total length in feet of cracks or total area in square feet for raveling and pattern cracks are recorded. The defects found in a sample area are linearly extrapolated for the entire discrete area, and this total length (or area) of defect is divided by the area of the discrete area to give a defect density. In the third step of the procedure, a weighted defect density of the discrete area is obtained by multiplying a given defect density times the weighting factor for that defect type. Weighting factors used in the Navy procedure are shown in Table 1. The final step is to compute a numerical condition rating for each facility (runway, taxiway, etc.). The weighted defect density for each discrete area is multiplied by the ratio of the discrete area over the total facility area to produce the weighted defect density for the facility. These values for each type of defect are then summed to give the total average weighted defect density for the facility.

The purpose given for development of the numerical defect density procedure was to aid in determining the suitability of airfield pavement

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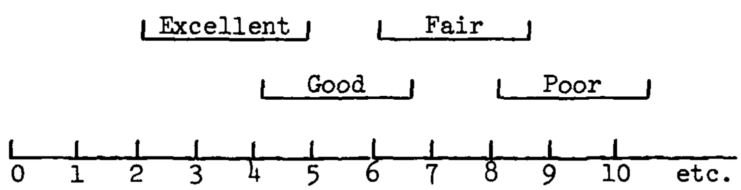
* A table of factors for the conversion of U. S. customary units of measurement to metric (SI) units is presented on page ii.

Table 1. Defect Severity Weights - Navy

Asphaltic Concrete		Portland Cement Concrete	
Defect	Severity Weight	Defect	Severity Weight
Depression	9.0	Depression	9.0
Rutting	9.0	Shattered Slab	9.0
Broken-up Area	9.0	Faulting	8.5
Faulting	8.5	Spalling	7.5
Raveling	7.0	Scaling	7.0
Erosion-Jet Blast	7.5	"D-Line" Cracking	6.5
Longitudinal, Transverse, or Longitudinal Construction Joint Crack	3.0	Pumping	4.0
Pattern Cracking	3.0	Poor Joint Seal	3.0
Patching	3.5	Corner Break	3.0
Reflection Crack	1.5	Intersecting Crack	3.0
Oil Spillage	1.5	Longitudinal or Transverse Crack	1.5

surfaces for aircraft operational requirements and to establish an unbiased, uniform basis for initiating maintenance and repair efforts. A comparison between the new numerical procedure and the old subjective rating system is as follows:



TEXAS METHOD

The Texas Highway Department[6] has implemented a condition rating procedure (developed by the Texas Transportation Institute) for the following purposes:

a. To define the present condition of the roadway.

b. To compare the present condition with the past condition to predict the future condition of the roadway.

c. To determine maintenance needs in terms of materials, equipment, manpower, and dollars.

d. To establish maintenance priorities based upon available resources.

e. To identify those maintenance activities that provide the greatest return for the maintenance investment.

A two-man team collects the data, which results in a numerical evaluation for the pavement. The roadway is divided into segments based on differences in observed distress, construction types, etc. If the roadway segment is less than 1 mile in length, the rating team stops and inspects the roadway at two locations for 100 ft in front of and in back of the vehicle. For roadway segments greater than 1 mile, the rating team stops in proportion to the number of miles evaluated. The extent of distress is defined as a percent of the lane area displaying that type of distress. The extent of distress is then separated into three categories or groups as shown in Tables 2 and 3. The percent area for different distress types varies, as shown in the reference document.[6]

The pavement rating score is obtained by subtracting "deduct values" associated with the various forms of pavement distress from 100. A score of 100 indicates a pavement without observable distress. Deduct values for flexible and rigid pavements are shown in Tables 2 and 3, respectively. A manual of definitions including photographs of each type of distress is given. Three severity levels--slight, moderate, and severe--are used. Pavement roughness is considered through measurements with the Mays Ride Meter, and deduct points are used for roughness. The Texas method also accounts for localized failures and gives deduct values of 20, 30, and 40 for the three levels of failure. A computer program for data reduction has been prepared.

CERL

CERL has developed a condition rating procedure for the Air Force[7-11] to provide the Air Force with (a) a method of describing and/or determining the relative condition of airfield pavements and (b) procedures for evaluating the consequence of using various maintenance strategies to extend the service life of existing pavements. The procedure has the following objectives:

Table 2. Deduct Values for Flexible Pavement - Texas

Type of Distress	Degrees of Distress	Extent or Amount of Distress (1)	(2)	(3)
Rutting	Slight	0	2	5
	Moderate	5	7	10
	Severe	10	12	15
Raveling	Slight	5	8	10
	Moderate	10	12	15
	Severe	15	18	20
Flushing	Slight	5	8	10
	Moderate	10	12	15
	Severe	15	18	20
Corrugations	Slight	5	8	10
	Moderate	10	12	15
	Severe	15	18	20
Alligator Cracking	Slight	5	10	15
	Moderate	10	15	20
	Severe	15	20	25
Patching	Good	0	2	5
	Fair	5	7	10
	Poor	7	15	20

Deduct Points for Cracking

	Sealed			Partially Sealed			Not Sealed		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Longitudinal Cracking:									
Slight	2	5	8	3	7	12	5	10	15
Moderate	5	8	10	7	12	15	10	15	20
Severe	8	10	15	12	15	20	15	20	25
Transverse Cracking:									
Slight	2	5	8	3	7	10	3	7	12
Moderate	5	8	10	7	10	15	7	12	15
Severe	8	10	15	10	15	20	12	15	20

Failures				20	30		40	
Mays Ride Meter	Deduct Points	50	40	30	20	10	5	0
	SI	2.4	2.7	2.9	3.1	3.3	3.5	3.7

Table 3. Deduct Values for Rigid Pavement - Texas

Type of Distress	Degrees of Distress	Extent or Amount of Distress (1)	(2)	(3)
Pumping	--	20	40	60
Failures/Mile	--	20	30	40
Surface Deterioration	Slight	5	10	20
	Moderate	10	20	30
	Severe	20	40	60
Spalling	Slight	5	10	15
	Moderate	10	15	20
	Severe	20	40	60
Longitudinal Cracking	Slight	5	10	15
	Moderate	10	15	20
	Severe	15	20	25
Patching	Good	0	2	5
	Fair	5	7	10
	Poor	7	15	20
Faulting	Moderate	5	15	--
	Severe	15	40	--
Crack Spacing	Closed	0	10	--
	Open	15	40	--
% Intersecting Cracks	Moderate	5	15	--
	Severe	15	40	--
Joint Spacing	Information Only			
Transverse Cracking				
If joint spacing is less than 20 ft:				
	Slight	5	10	20
	Moderate	10	20	30
	Severe	15	30	40
If joint spacing is greater than 20 ft:				
	Slight	0	5	10
	Moderage	5	10	20
	Severe	10	15	30
Joints	(Sealed)	0	10	20

Mays Ride Meter								
	Deduct Points	50	40	30	20	10	5	0
	SI	2.4	2.7	2.9	3.1	3.3	3.5	3.7

a. To indicate the present condition of the pavement in terms of structural integrity and operational surface condition.

b. To provide the Air Force with a common index for comparing the condition and performance of all base pavements and to provide the Air Force with a rational justification for in-depth pavement evaluations.

c. To provide feedback on pavement performance for validation or improvement of current pavement design procedures.

The condition survey consists of first dividing the pavement into "features" based on the pavement's design, construction history, and traffic area. Each feature is divided into "sample units" of approximately 20 slabs for PCC pavements (where joint spacings are less than 30 ft) and a 5000-sq-ft area (50 by 100 ft) for AC pavements. The field survey consists of walking over the sample unit, measuring each distress type and severity, and recording the data on the data sheet for the sample unit. A summary of the distresses and the severities of each distress contained in the sample unit is compiled on the survey data sheet. The pavement condition index (PCI) is determined from the following steps and as outlined in Figure 1:

a. The feature is inspected and distress is identified according to the distress identification manual.

b. A deduct value is determined from the appropriate curve for each distress type, density, and severity level.

c. The total deduct value (TDV) is determined by summing all deduct values from each distress condition observed.

d. The corrected deduct value (CDV) is determined based on the TDV and the number of distress conditions observed with individual deduct values greater than five points.

e. The PCI is calculated as PCI = 100 - CDV .

f. The pavement condition rating is determined as shown in step 6, Figure 1.

CERL suggests inspection of statistically selected sample units to reduce time and effort of the inspection survey. The work of CERL has shown that the use of statistical sampling does not produce significant loss of accuracy. The statistical sampling is optional, and the entire pavement feature may be inspected, if desired. The number of sample units to be inspected is dependent upon the desired confidence

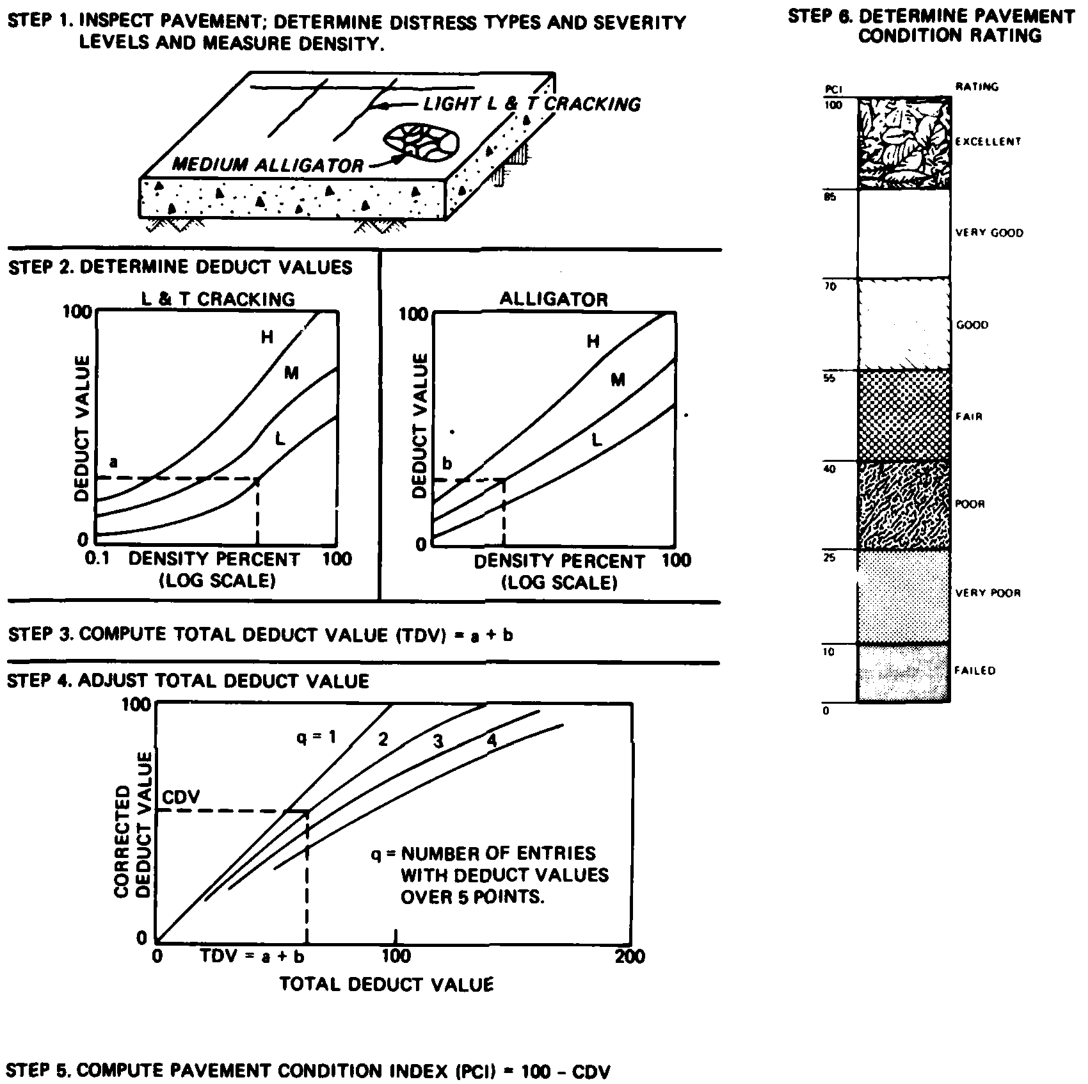


Figure 1. Steps for determining airfield pavement condition rating

level, the standard deviation of the PCI, and the total number of samples in a feature. The selection of the location of those sample units to be inspected is based on a statistical selection process. A simple procedure is presented for selection of the sample units.

CERL recommends that pertinent pavement information be documented as a part of the condition survey. This consists of construction history, traffic history, weather data, plans and cross sections, drainage

features, grades, frost action, joint types and conditions, and photographs of pavement conditions. Most of this information is already documented for Air Force pavements.

DISCUSSION OF EXISTING PROCEDURES

All of the condition survey procedures reviewed have certain common features, while certain features of some procedures appear more desirable than others. Each procedure was developed for a particular application and tailored to meet the criteria of the user. Probably, the oldest procedure reviewed was the Corps of Engineers/Air Force method that was designed for application on Army and Air Force military airfields. This procedure had an objective approach for rigid pavements, accounting for specific types of distress and the density of distressed slabs. However, the method for flexible pavements was based almost totally on the opinion of the rater, although the various types of distress observed were noted.

The Navy, Texas, and CERL methods all make use of deduct values (weighting functions) for various types of distress. This provides a greater penalty for distress types that more adversely affect performance. The Navy recognizes 11 distress types for flexible pavement and 11 types for rigid pavement. The CERL procedure gives 16 distress types for flexible pavement and 15 for rigid. Texas shows 10 flexible and 11 rigid pavement distress types. Texas is the only procedure that assigns deduct values to localized pavement failures and to roughness (Mays Ride Meter) measurements. The Navy method recognizes skid resistance (James Braking Decelerometer), but apparently does not consider it in the condition rating. CERL and Texas are the only methods to consider various degrees of distress (severity levels), although all other methods do recognize distress density. The CERL procedure has a continuous density deduct curve, whereas the Texas method has a table of discrete values. The Texas method is, of course, designed for highway application, and much of the information is not applicable to airport pavements. The Navy, Texas, and CERL procedures use photographs and distress definitions to assist in identification of distress types and severity levels.

Statistical sampling techniques are recommended by the Navy and CERL and are offered as optional techniques to complete sampling. The only difference in statistical sampling by the Navy and CERL is the sample size. The Navy selects individual slabs or a strip of adjacent slabs transverse to runway or taxiway center line for rigid pavements. CERL uses a group of 20 slabs as a sample unit. The Navy uses a 50- by 50-ft area of flexible pavement as a sample unit, while CERL uses a 5000-sq-ft area as a sample unit. There seems to be no particular advantage or disadvantage to sample size as long as the size is convenient to the inspector and an adequate number are measured to provide a representative picture of the surface condition. Both the Navy and CERL base the number of sample units inspected on a 95-percent confidence level.

The CERL method appears to be the most comprehensive method available. It provides the best guidance for distress identification, accounts for a broader spectrum of distress conditions appropriate to airport pavements, and accounts for distress type, severity level, and distress density.

It is noted here that the deduct values, sample size, and other restrictions must be adhered to since these were used in development of the procedure. Any changes that might be found desirable for adaptation to civil airports must be made after experience is gained. For example, the addition of new distress types, or the deletion of existing ones, cannot arbitrarily be made without the possibility of affecting the entire procedure. Because the CERL procedure does not consider friction and roughness measurements as an input to the condition rating, future study should be devoted to incorporation of these variables into the procedure.

DEVELOPMENT OF PROPOSED PROCEDURE

BASIS FOR PROCEDURE DEVELOPMENT

The performance analysis scheme developed herein is essentially an extraction of material from existing procedures. The procedure developed by CERL makes up the basis of the scheme, with outstanding features of other procedures added where appropriate. This section of the report describes development of the procedure and defines the various items that have been included. A condensed version providing only the condition survey method is presented in Appendix A.

The work performed by CERL for the Air Force Systems Command consists of a maintenance management system and is described in a five-volume report.[7-11] The surface condition rating procedure, an important part of that system, is essentially the procedure recommended for FAA use. Development of the PCI first required identification and description of the various types of distress occurring on airfield pavements. Surveys made on 123 different pavement sections coupled with existing distress nomenclature resulted in an identification manual with photographs and definitions of 15 types of distress for rigid pavement and 16 types of distress for flexible pavement with three severity levels given for each type. Instructions for measuring the density (amount) of each distress type are also given in the manual. This identification manual is included herein as Appendix B.

Deduct values, which are weighting functions that measure the impact that each pavement distress has on pavement performance (structural integrity and surface operational condition), were derived by comparing measured distress levels to subjectively rated distress levels. A general equation defining the PCI was set as:

$$PCI = 100 - \sum_{i=1}^{P} \sum_{j=1}^{M_i} a(T_i S_j D_{ij})$$

where

P = total number of distress types

M_i = number of severity levels of the i^{th} type of distress

$a(T_i S_j D_{ij})$ = deduct value for a given distress type T_i at severity level S_j and density D_{ij}

i = counter for distress types

j = counter for severity levels

Initial deduct values were determined according to the scale in Table 4 by subjectively estimating the maximum deduct for each distress and severity level at maximum density and assuming a curvilinear relationship between deduct value and density.

Table 4. Descriptive Rating Scale - CERL

Rating	Descriptive Categories
100-86	Excellent
85-71	Very Good
70-56	Good
55-41	Fair
40-26	Poor
25-11	Very Poor
10-0	Failure

During initial stages of development and the first field tests, sample unit sizes of 20 slabs for PCC pavements and 5000 sq ft for AC pavements were selected. (The area of the 20 slabs will vary considerably depending on slab size, but specifying the number of slabs gives a consistent number of joints and allows the edges of the sample unit to be along the joints.) These sample unit sizes were felt adequate for evaluation of distresses and computation of the PCI. Field tests were first conducted on five rigid pavements and four flexible pavements. Experienced pavement engineers subjectively rated each pavement according to the scale in Table 4. Results of these ratings were termed pavement condition rating (PCR). Deduct values developed for each distress type

and severity level are similar to the example shown in Figure 2. Appendix A gives a complete set of deduct curves for all recognized distress types for both flexible and rigid pavements.

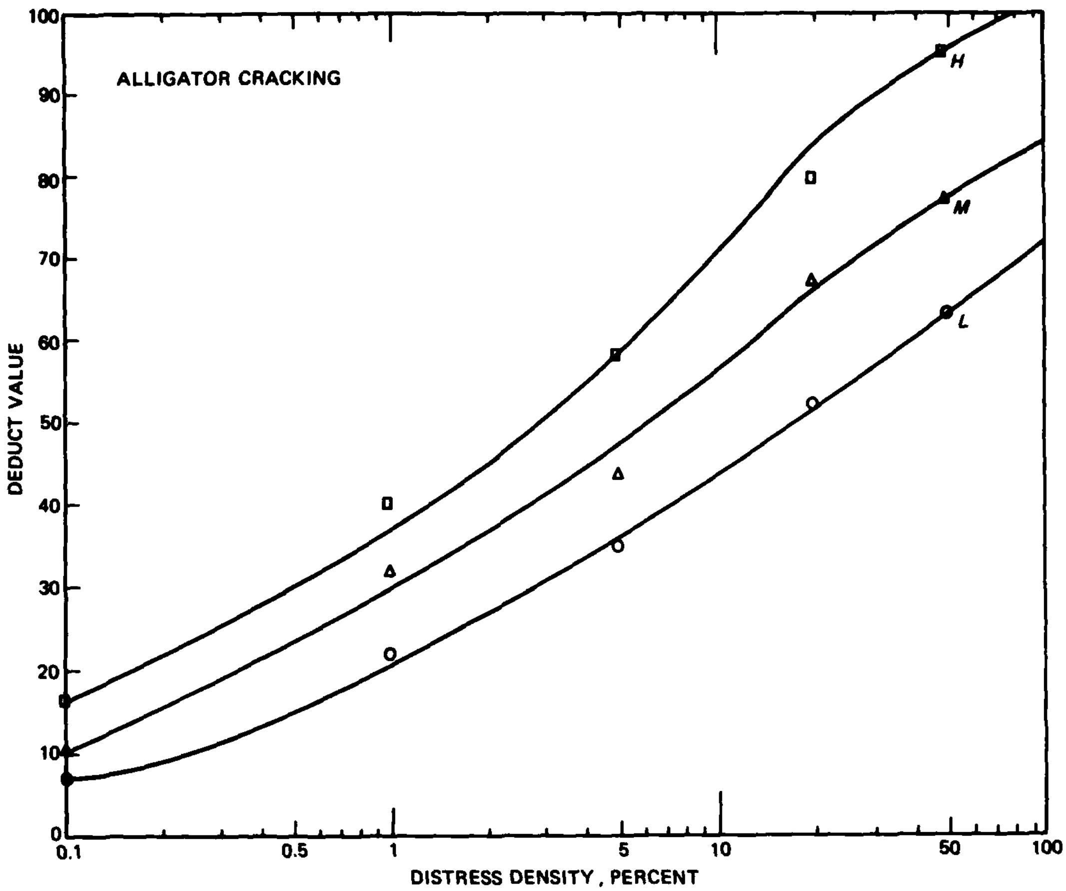


Figure 2. Example of deduct value versus density curves for alligator cracking

Additional field tests were performed on 35 rigid pavements and 69 flexible pavements to further refine and validate the procedures. It was determined that an adjustment to the deduct values was necessary when a pavement contained several distress types. This adjustment was determined by comparison of the PCI to PCR. Since distress types with deduct values less than 5 had little effect on the pavement condition, only those greater than 5 are considered in the final computation. Figures 3 and 4 show the adjustment curves developed to account for

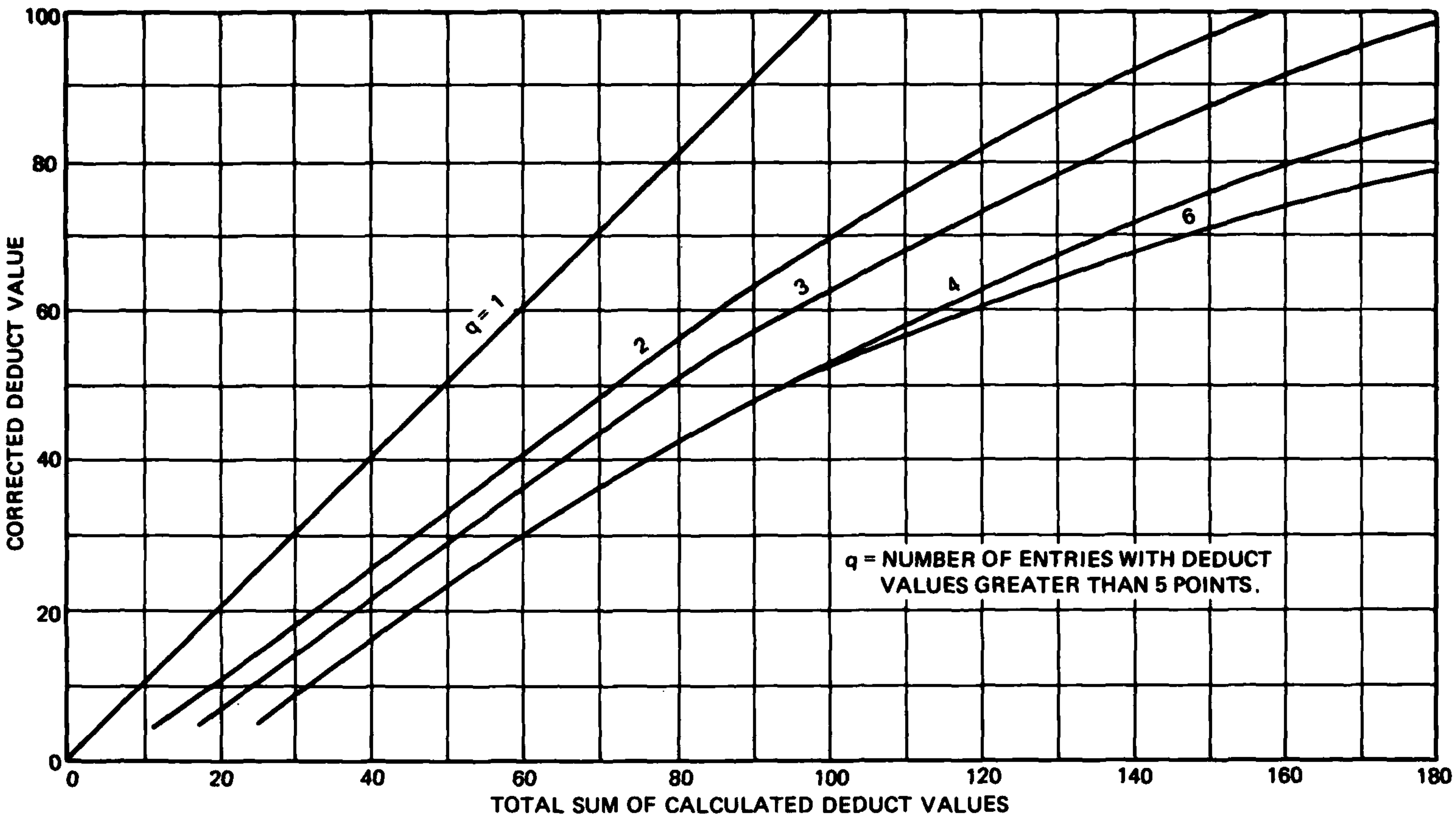


Figure 3. Adjusted deduct values for multiple distress in flexible pavements

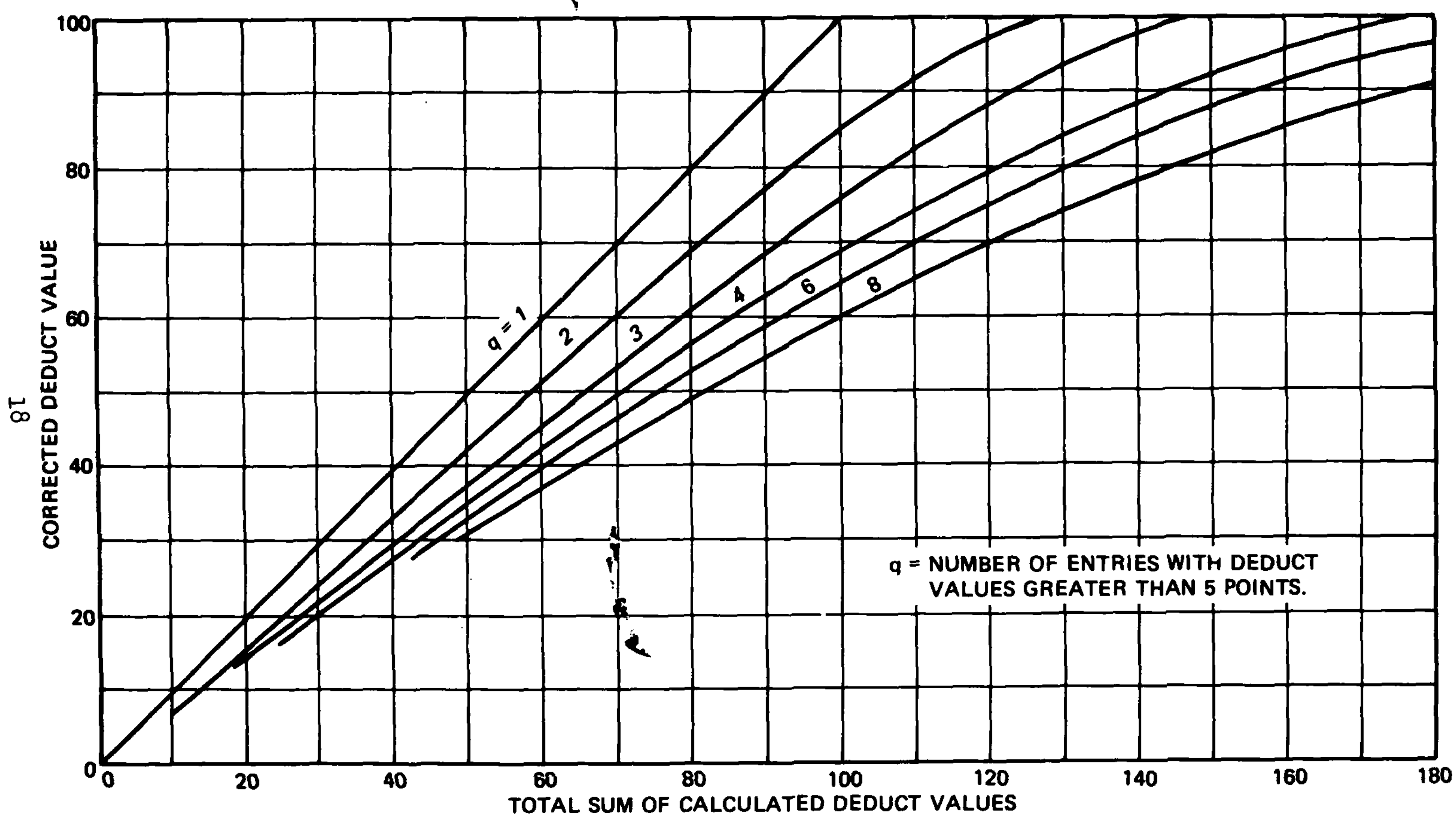


Figure 4. Adjusted deduct values for multiple distress in jointed concrete pavements

multiple distress types on given pavement sections. The value q denotes the number of distress types found with a deduct value greater than 5. The corrected deduct value from Figures 3 or 4 is then used to compute the PCI.

It can be seen that the procedure described has been fitted to the PCR results, which are a composite rating by a group of pavement engineers. Figures 5 and 6 are comparisons of the PCI and the PCR for all pavements investigated by CERL. Once the PCI has been thus developed, it provides a tool for uniform and consistent pavement ratings. The only potential problem is that the PCR used in the CERL work was by Air Force engineers, and their criteria might be somewhat different from FAA and civil airport engineers. This possibility of different criteria will need to be checked out and any necessary adjustments made prior to implementation of the procedure to civil airports.

SAMPLING AND INSPECTION TECHNIQUES

An important aspect of the condition survey is the selection of areas or sample units to be inspected. A *preliminary survey* should first be made after reviewing the construction history and stationing or marking off the pavements in increments of usually 100 ft. The next step would be to divide the pavements into features such that each feature (a) has consistent structural thickness and materials, (b) was constructed at one time, (c) is located in one traffic area (pavements should be divided according to traffic usage), and (d) is generally of the same overall condition based on the preliminary survey. The pavement construction information is available from the local FAA office or the airport engineer. Traffic data can be obtained from the airport operations personnel, airlines that operate at that airport, and the airport master plan.

Once the pavement features are defined, these are then further subdivided into sample units consisting of approximately 20 slabs in PCC pavements and approximately 5000 sq ft (such as 50 by 100 ft) in AC pavements. Each sample unit should be numbered for reference purposes. All distress types in a given sample unit are recorded (see procedure in Appendix A) and used to compute the PCI for the sample unit.

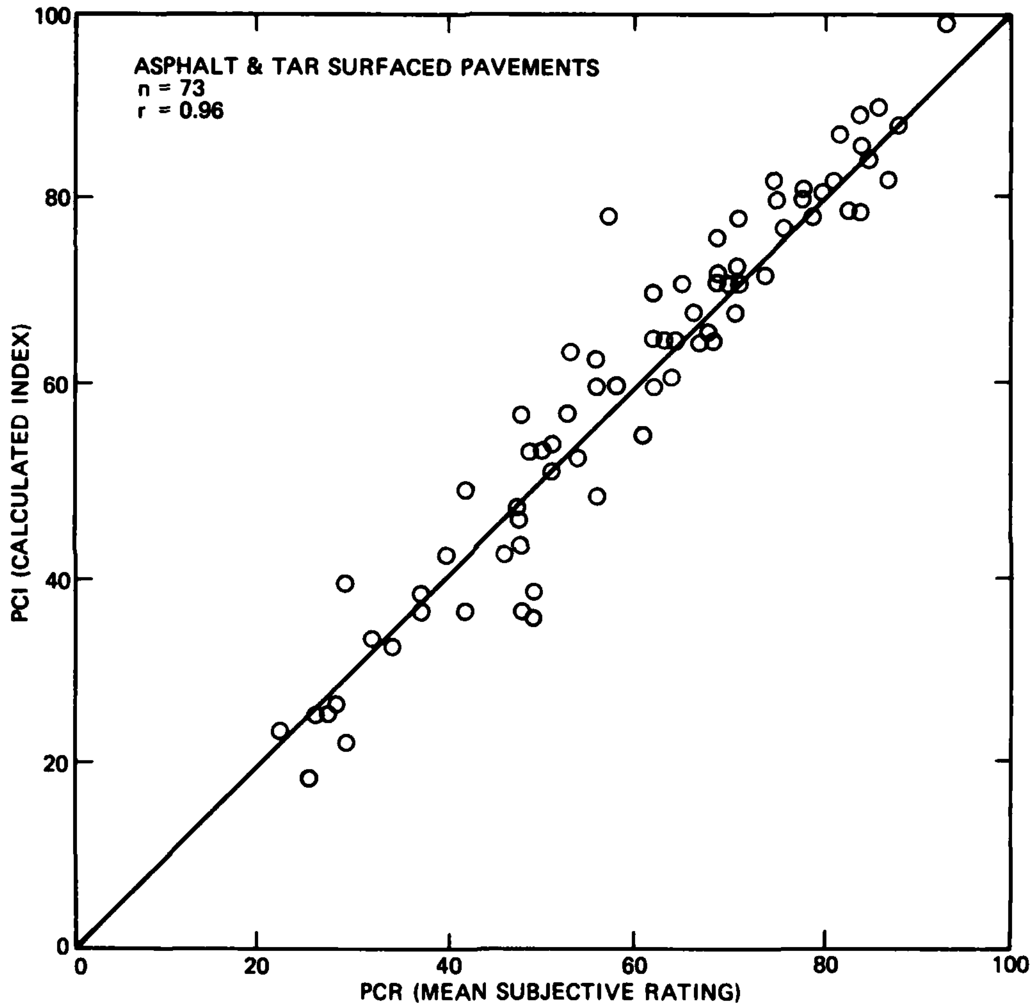


Figure 5. Correlation between PCR and PCI for all flexible pavement sections surveyed

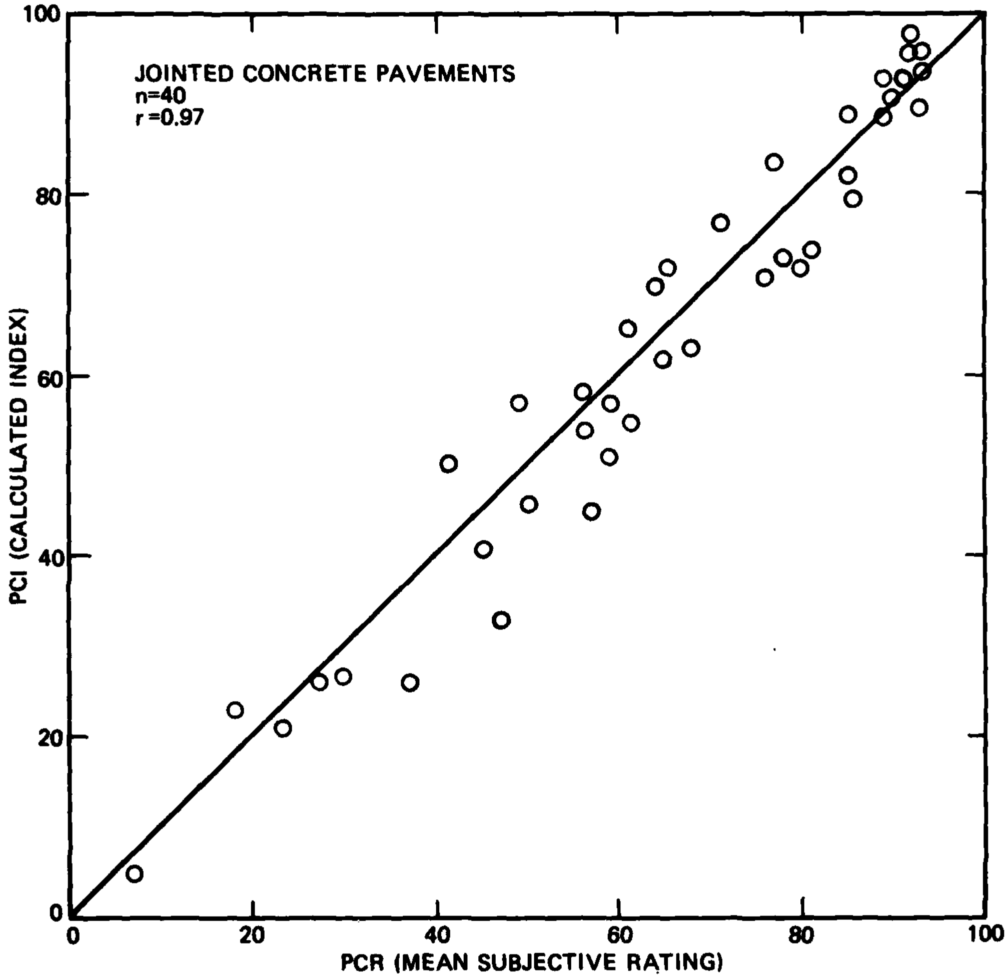


Figure 6. Correlation between PCR and PCI for jointed rigid pavement sections surveyed

The field survey may consist of the inspection of each sample unit within a feature or the inspection of a sufficient number of statistically selected sample units to provide representative results of the entire feature.

The use of statistical sampling is recommended by both CERL and the Navy. Statistical sampling can result in considerable savings of manpower, funds, and time and, yet, will not cause any significant loss in accuracy when properly applied. Assuming a normal distribution of the data, the number of sample units to be surveyed to provide a 95-percent confidence level can be determined from

$$n = \frac{N\sigma^2}{\left(\frac{e^2}{4}\right)(N-1) + \sigma^2}$$

where

n = number of sample units to be inspected

N = total number of sample units in feature

σ = one standard deviation in PCI from one sample unit to another within the feature

e = allowable error in determining the true PCI

Data collected by CERL in development of the PCI gave average σ values of 10 and 15 for flexible and rigid pavements, respectively. These values should be confirmed on civil airport pavements as experience is gained. The above equation is presented graphically in Appendix A (Figure A-6) to simplify its use in application.

The number of samples n obtained from the equation is the minimum number to be inspected in a given pavement feature in order to have 95 percent confidence that the PCI is within five points. Selection of the particular sample locations should be such as to provide a representative PCI for the entire feature. The original CERL procedure called for stratification of the pavement feature into a number of parts with an equal number of sample units being selected from each strata. This system was later improved by use of a "systematic random technique." This technique assures that the selected sample units will be equally

spaced and thus allow for obtaining a PCI profile for the feature. The new technique is also easier to apply. The selection of the sample unit interval is determined from the formula

$$i = \frac{N}{n}$$

where

i = interval of sample units

N = total number of sample units in the feature

n = number of sample units to be inspected

The first sample unit to be inspected should be selected at random between 1 and i.

When it is desired to add additional samples to the survey because it is felt that very poor or excellent units were omitted, then the following equation must be used

$$PCI_f = \frac{(N - A)}{N} \overline{PCI_1} + \frac{A}{N} \overline{PCI_2}$$

where

PCI_f = mean PCI of feature obtained from total number of units inspected

N = total number of sample units in the feature

A = number of additional sample units

$\overline{PCI_1}$ = mean of PCI for n number of randomly selected units

$\overline{PCI_2}$ = mean of PCI for additional sample units

As many additional sample units can be added as might be desirable. The $\overline{PCI_2}$ is the mean PCI of all the additional sample units.

ITEMS OF CONDITION SURVEY

The condition survey procedure proposed is aimed at not only measuring the present condition of a pavement, but also documenting those factors that may have contributed to the past performance and determining whether that performance has been acceptable. A pavement's performance is influenced by many factors with each factor having an effect on other factors. Those factors considered to have the greatest

effect on pavement performance are design/construction, environment, maintenance, and traffic. Some of these factors may not seem especially important to an individual airport; but in the comparison of the performance of many airport pavements, seemingly unimportant factors may become key factors. A much greater effort will be required when making the first survey at a particular airport than will be required by periodic follow-up surveys. Every effort should be made to record all pertinent information. Results of the latest structural evaluation study should also be included in the condition survey report.

DESIGN/CONSTRUCTION RECORDS

The materials that compose a pavement and the methods by which these materials are constructed have a major influence on how well a pavement performs. Certain unique distress types are characteristic to particular materials. Certain distress conditions occur as the result of particular construction practices. In order to properly analyze performance, the materials used and the construction methods applied need to be known. The survey procedure of Appendix A provides a form for documentation of the important design and construction factors. Any unusual circumstances that occurred during construction that may have a bearing on performance should be noted either on the form or as a narrative in the condition survey report.

ENVIRONMENTAL AND GEOGRAPHICAL FACTORS

Pavements deteriorate with time due to environmental factors such as temperature extremes, rainfall, and freeze-thaw cycles. Local geographical conditions such as soil type, water table, and surface and subsurface drainage conditions also affect performance. Rainfall and temperature data can be obtained from local weather stations, generally located at the airport. Any previous soil borings should provide data on water table and soil conditions. Local personnel may have observations as to rainfall runoff and drainage problems.

MAINTENANCE RECORDS

The present condition of a pavement may be related to the maintenance attention it has received. Also, the degree of maintenance that has been required to maintain a serviceable condition would indicate how well the pavement has performed. Maintenance data should be available from the airport engineer and maintenance personnel. A form has been prepared for documentation of this information.

TRAFFIC DATA

A knowledge of the traffic that has been applied to a pavement is a key factor in assessing performance. The using aircraft compared to the design aircraft tell if the pavement is being used at design capacity. The important items of concern are the type aircraft, operating gross loads, frequencies of operations, and pavement facilities used. Traffic data can be obtained from the airport operations personnel or the operating airline companies at the airport.

STRUCTURAL RATING

Most airports perform periodic structural evaluations to determine pavement load-carrying capacity. These evaluations may be based on nondestructive test results or conventional test pits and borings. The results of such structural evaluations are related to condition ratings, and both types of information are needed to analyze total pavement performance. The structural evaluation gives a picture of the pavement's ability to withstand load stresses and resist deformation and cracking. The condition rating is a picture of how well the pavement is performing its job of supporting traffic loads. A form for recording the structural rating information is given in Appendix A.

DISTRESS CONDITION NARRATIVE

The PCI gives a composite rating of the surface condition, and the field work sheets indicate the types of distress, the density, and severity levels. However, a narrative description of the overall pavement condition of each pavement feature should be included in the

condition survey report. Singular occurrences of any serious defects found should be noted. Also, the most frequently occurring defects might be noted with possible explanations of their cause. A description of other features such as pavement surface texture, runway shoulders, overrun areas, rubber buildup on runways, potential drainage problems, etc., can be inserted into the narrative.

DISCUSSION OF PAVEMENT PERFORMANCE EVALUATION

There are two modes of pavement performance--functional and structural. Functional performance may be defined as the ability of a pavement to provide the intended service of carrying traffic in a safe and acceptable manner. Structural performance refers to the ability of a pavement to support applied traffic loadings without damage to the pavement structure. These two types of performance are interrelated, and one may be influenced by the other. Structural distress may well result in poor functional performance. However, poor functional condition does not necessarily suggest structural problems.

The FAA-sponsored research has resulted in structural rating procedures based on nondestructive testing (NDT) techniques. These procedures can determine the load-carrying capacity of an existing pavement and determine overlay thickness requirements. These procedures do not, however, consider the functional condition of the pavement and only account for the structural support. An airport pavement may be rated structurally sound and suited for the design aircraft loadings but may be unacceptable for use due to surface problems such as roughness, poor friction, surface raveling, cracks and faulting, or many other types of surface deficiencies. Predictions of remaining pavement life become difficult because the amount of life used by previously applied aircraft is not readily assessable.

Since the PCI is a rating of an existing pavement's surface condition, it measures functional performance with implications of structural performance. Certain cracking, raveling, weathering, polished aggregates, scaling, etc., may not result in decreased structural capacity but may restrict functional usage. On the other hand, distress types such as faulting (settlement), rutting, pumping, etc., reflect a structurally deficient pavement and reduce the functional desirability. The PCI for a typical runway is shown in Figure 7. Nondestructive test results for the same runway are not available, but the PCI and the NDT data should be somewhat complementary, and a complete evaluation should include both.

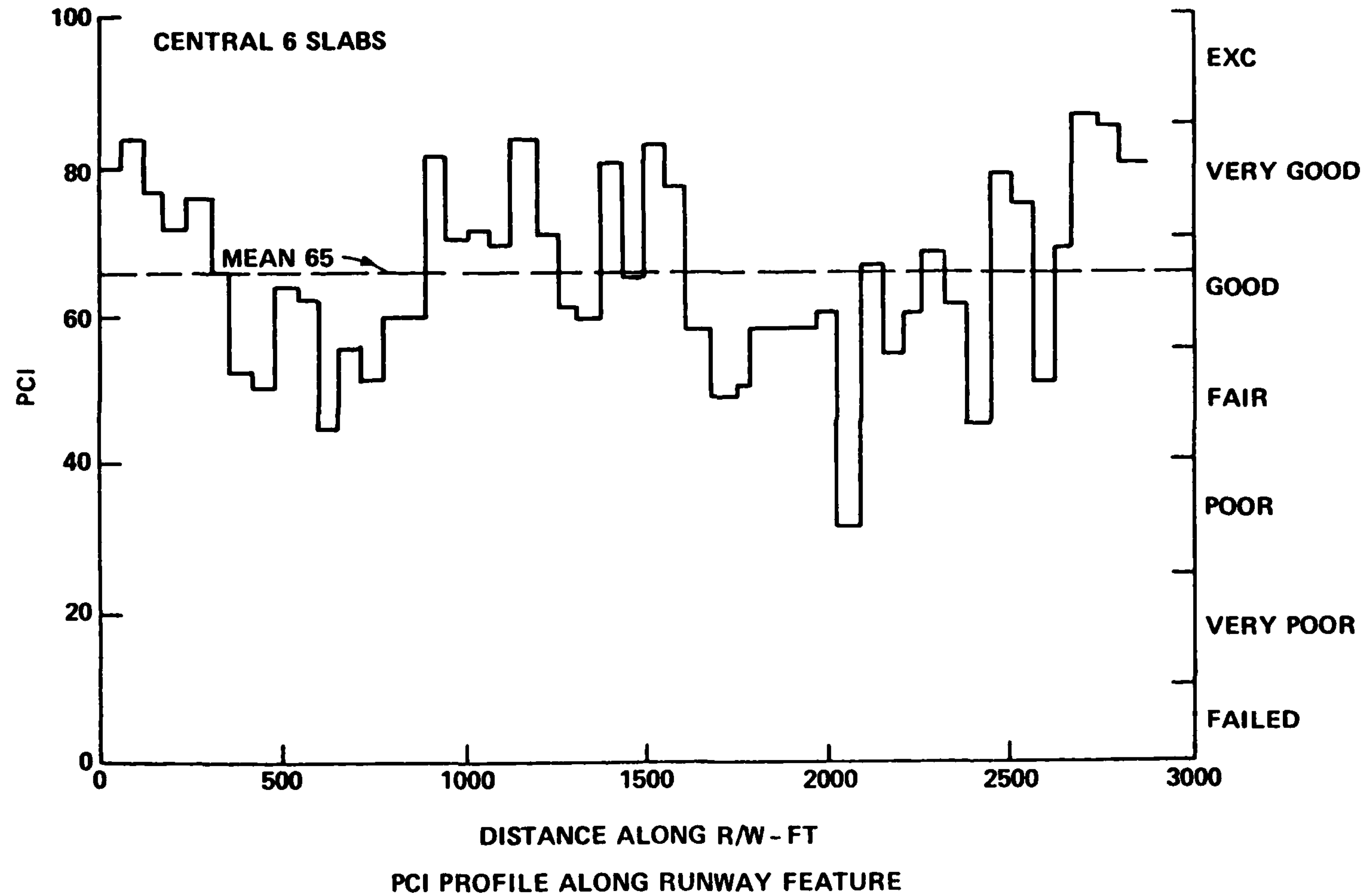


Figure 7. Typical PCI profile for runway pavement

The PCI measured on a number of pavements of known service age has been presented in the work by CERL, as shown in Figures 8 and 9. A band has been drawn on each figure to include those pavements considered to have "normal" deterioration. Pavements plotted below the band have deteriorated at a rapid rate as denoted by "high." Likewise, "low" indicates better than normal performance. The graphs can be used to indicate whether a pavement's surface is deteriorating at a low, normal, or high rate as compared to those pavements used in developing this procedure. This type of information is of interest in analyzing the performance of airport pavements. Periodic PCI determinations on the same pavement will show the change in performance level with time. The nondestructive evaluation may not change drastically with time unless there is a significant change in structural support. The PCI, however, will measure the gradual deterioration with time. The PCI probably should be performed as a prerequisite for an NDT evaluation.

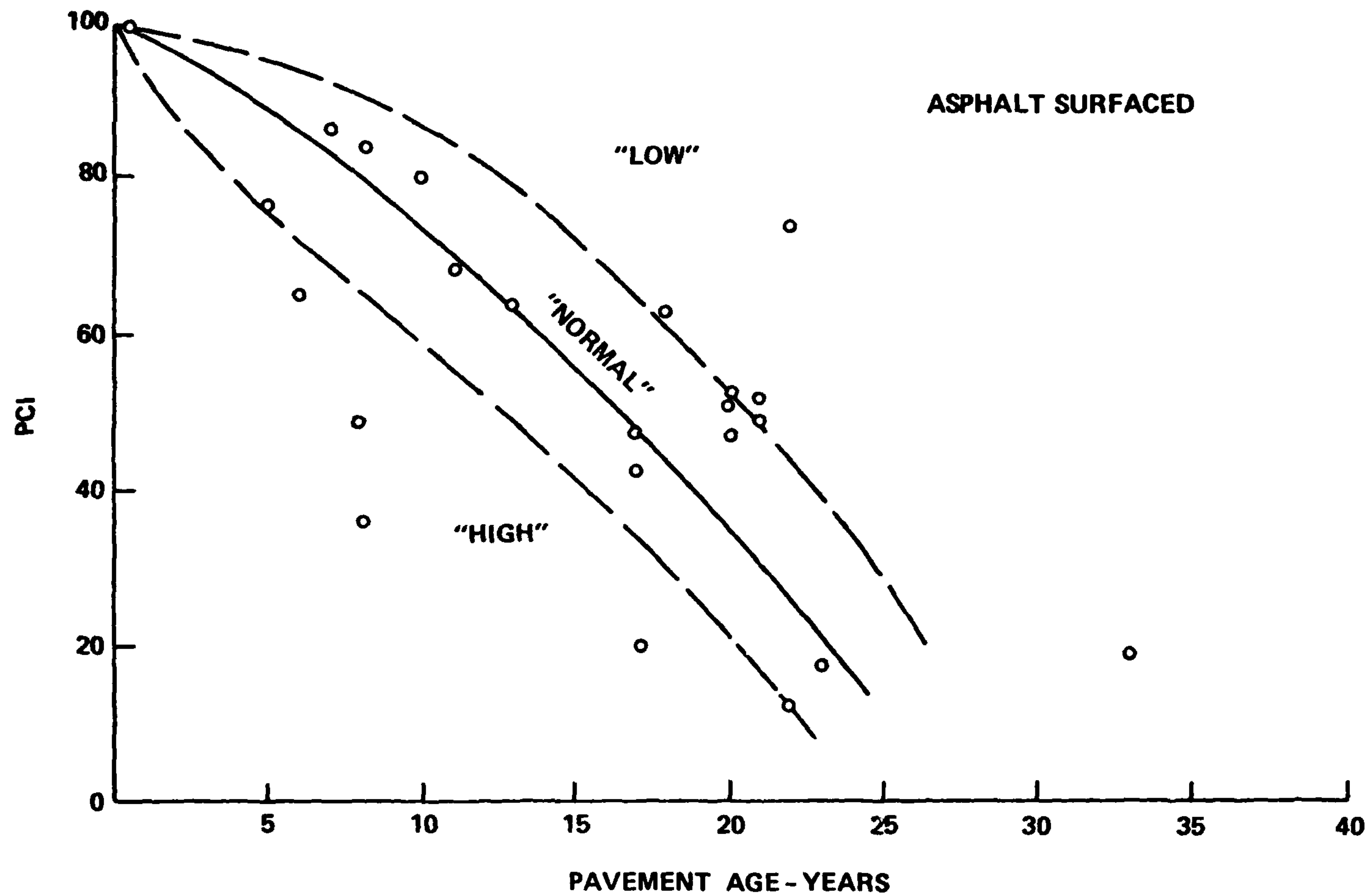


Figure 8. PCI of flexible pavement features versus time since construction (or since last overlay)

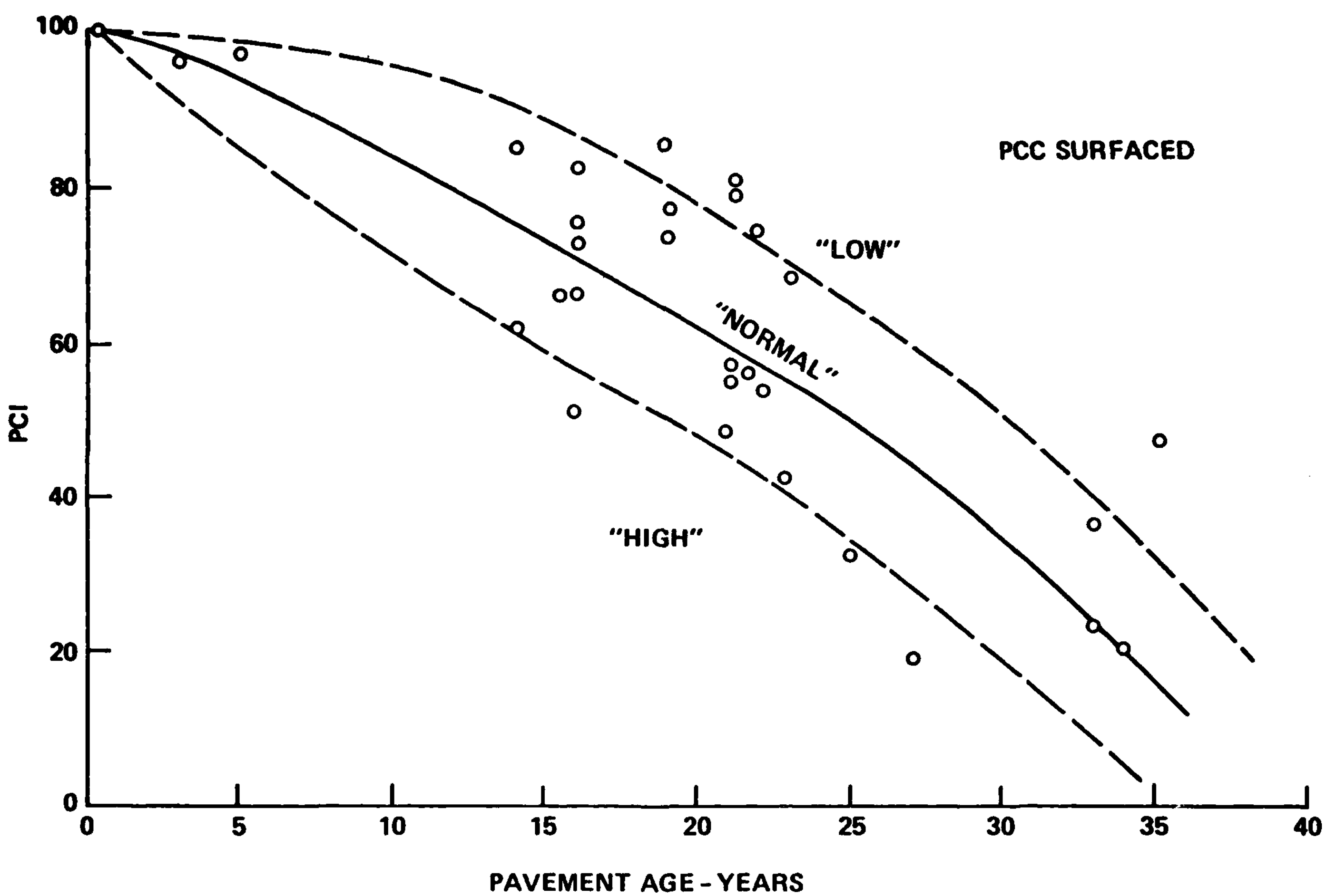


Figure 9. PCI of jointed rigid pavement features versus time since construction

CONCLUSIONS AND RECOMMENDATIONS

As a result of this state-of-the-art review of pavement condition survey techniques, the following conclusions were drawn:

a. The condition rating procedure developed by CERL for the Air Force was rated as the most comprehensive method reviewed and selected as the method with the most potential for use on civil airports.

b. The condition rating procedure suggested for civil airports offers a uniform method for assessing functional performance levels of airport pavements and for monitoring changes in performance with time.

Recommendations as to a condition survey procedure for civil airports are:

a. The condition rating procedure proposed for use on civil airports should be validated through demonstration projects on several airports.

b. After acceptance by the FAA, the procedure should be implemented at all civil airports as a means of monitoring pavement performance.

c. The PCI should be used with NDT evaluation procedures to give a more complete evaluation of both functional and structural performance. Consideration should be given to requiring a condition rating survey prior to performing any structural (load-capacity) evaluation.

d. Further study should be devoted to the use of the PCI for defining maintenance and rehabilitation needs.

e. Consideration should be given to incorporating friction and roughness measurements to the total condition evaluation procedure.

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APPENDIX A: CONDITION SURVEY PROCEDURE

GENERAL

This appendix gives the detailed procedure for performing a pavement condition survey at civil airports. The procedure is presently limited to flexible pavements (all pavements with conventional bituminous concrete surfaces) and jointed rigid pavements (jointed nonreinforced concrete pavements with joint spacing not exceeding 25 ft). Specific objectives for the condition survey are:

- a. To determine present condition of the pavement in terms of apparent structural integrity and operational surface condition.
- b. To provide FAA with a common index for comparing the condition and performance of pavements at all airports and also provide a rational basis for justification of pavement rehabilitation projects.
- c. To provide feedback on pavement performance for validation and improvement of current pavement design, evaluation, and maintenance procedures.

The airport pavement condition survey and the determination of the PCI are the primary means of obtaining and recording vital airport pavement performance data. The condition survey for both rigid and flexible pavement facilities consists principally of a visual inspection of the pavement surfaces for signs of pavement distress resulting from the influence of aircraft traffic and environment.

BASIC AIRPORT INFORMATION

A considerable amount of basic airport data is incorporated into the condition survey report. Most of this information is contained in construction and maintenance records and in previous condition survey reports. To facilitate report preparation, the basic data should be accumulated and maintained by the airport engineer. The following items should be compiled for subsequent use during the condition survey:

- a. Design/construction/maintenance history. The history of maintenance, repair, and reconstruction from original construction of the airport pavement system to the present should be maintained. These data should reflect airport paving projects

and airport change projects accomplished either in-house or by a contractor.

b. Traffic history. Air carrier, commuter, cargo, and military aircraft traffic records, including aircraft type, typical gross loads, and frequency of operation.

c. Climatological data. Annual temperature ranges and precipitation data should be obtained from the weather office nearest the airport.

d. Airport layout. Plans and cross sections of all major airport components, including subsurface drainage systems. These should be updated to reflect new construction upon completion of the project.

e. Frost action. If applicable, records of pavement behavior during freezing periods and subsequent thaws should be recorded.

f. Photographs. Photographs depicting both general and specific airport conditions should be taken.

g. Pavement condition survey reports. All previous pavement condition survey reports should be maintained to be referenced in the current report.

A series of data summary sheets has been devised and is presented in Figures A-1 through A-4. These summary sheets should be helpful to the personnel involved in obtaining and maintaining the necessary information. Narrative information pertaining to unusual problems, solutions, or attempted solutions to these problems should be included. This information would be beneficial in determining research needs as well as in providing a means of distributing information.

OUTLINE OF BASIC CONDITION RATING PROCEDURE

The steps for performing the condition survey and determining the PCI are described below and in Figure A-5:

a. Station or mark off the airport pavements in 100-ft increments. This is done semipermanently to assure ease of proper positioning for the condition survey. The overall airport pavements must first be divided into features based on the pavements design, construction history, and traffic area. A designated pavement feature, therefore, has consistent structural thickness and materials, was constructed at the same time, and is located in one airport facility, i.e., runway, taxiway, etc. After initially designating the features on the airport, make a preliminary survey. This survey shall entail a brief but complete visual survey of all the airport pavements. By

observing distress in an individual feature, it may be determined whether there are varying degrees of distress in different areas. In such cases, the feature should be subdivided into two or more features.

b. The pavement feature is divided into sample units. A sample unit for jointed rigid pavement is approximately 20 slabs; a sample unit for flexible pavement is an area of approximately 5000 sq ft.

c. The sample units are inspected, and distress types and their severity levels and densities are recorded. Appendix B provides a comprehensive guide for identification of the different distress types and their severity levels. The criteria in Appendix B must be used in identifying and recording the distress types and severity levels in order to obtain an accurate PCI.

d. For each distress type, density, and severity level within a sample unit, a deduct value is determined from the appropriate curve.

e. The total deduct value (TDV) for each sample unit is determined by adding all deduct values for each distress condition observed.

f. A corrected deduct value (CDV) is determined using procedures in the appropriate section for jointed rigid or flexible pavements.

g. The PCI for each sample unit inspected is calculated as follows:

$$PCI = 100 - CDV$$

If the CDV for a sample unit is less than the highest individual distress deduct value, the highest value should be used in lieu of the CDV in the above equation.

h. The PCI of the entire feature is the average of the PCI's from all sample units inspected.

i. The feature's pavement condition rating is determined from a figure that presents verbal descriptions of a pavement condition as a function of PCI value.

SAMPLING TECHNIQUES

Inspection of an entire feature may require considerable effort, especially if the feature is very large. This may be particularly true for flexible pavements containing much distress. Because of the time and effort involved, frequent surveys of the entire feature may be

beyond available manpower, funds, and time. A sampling plan has, therefore, been developed so that an adequate estimate of the PCI can be determined by inspecting a portion of the sample units within a feature. Use of the statistical sampling plan described here will considerably reduce the time required to inspect a feature without significant loss of accuracy. However, this statistical sampling plan is optional, and inspection of the entire feature may be desirable. The airport engineer should specify whether statistical sampling may be used. The condition survey proceeds as follows:

a. Determination of pavement feature. The first step in the condition survey is the designation of pavement features. Each facility such as a runway, taxiway, etc., is divided into segments or features that are definable in terms of (1) the same design, (2) the same construction history, (3) the same traffic area, and (4) generally the same overall condition. General features can be determined from pavement design and construction records and can be further subdivided as deemed necessary based on a preliminary survey. It is important that all pavement in a given feature be such that it can be considered uniform. As an example, the center part of some runways in the traffic lanes should be separate features from the shoulder portion outside the traffic lanes.

b. Selection of sample units to be inspected. The minimum number of sample units that must be surveyed to obtain an adequate estimate of the PCI of a feature is selected from Figure A-6. Once the number of sample units η has been determined from Figure A-6, the spacing interval of the units is computed from

$$i = \frac{N}{\eta}$$

where

i = spacing interval of units to be sampled
N = total number of sample units in the feature
η = number of sample units to be inspected

All the sample numbers within a feature are numbered and those that are multiples of the interval i are selected for inspection. The first sample unit to be inspected should be selected at random between 1 and i. Sample unit size should be 5000 sq ft (generally 50 by 100 ft) for flexible pavement and 20 adjacent slabs for rigid pavement. Figures A-7 and A-8 illustrate the division of a jointed rigid pavement and flexible pavement feature, respectively, into sample units.

Each sample unit is numbered so it can be relocated for future inspections, maintenance needs, or statistical sample purposes. Each of the selected sample units must be inspected and its PCI determined. The mean PCI of a pavement feature is determined by averaging the PCI of each sample unit inspected within the feature. When it is desirable to inspect a sample unit that is in addition to those selected by the above procedure, then one or more additional sample units may be inspected and the mean PCI of the feature computed from:

$$PCI_f = \frac{(N - A)}{N} \overline{PCI_1} + \frac{A}{N} \overline{PCI_2}$$

where

PCI_f = mean PCI of feature

N = total number of sample units in feature

A = number of additional sample units

$\overline{PCI_1}$ = mean of PCI for η number of statistically selected units

$\overline{PCI_2}$ = mean PCI for all additional sample units

It is necessary that each sample unit be identified adequately so that it can be relocated for additional inspections to verify distress data or for comparison with future inspections. Based on significant variation of sample unit PCI along a feature and/or significant variation in distress types among sample units, one feature should be divided into two or more features for future inspections and maintenance purposes.

DETAIL SURVEY PROCEDURE
FOR RIGID PAVEMENT

Each sample unit, or those selected by the statistical sampling procedure, in the feature is inspected. The actual inspection is performed by walking over each slab of the sample unit being surveyed and recording distress existing in the slab on the jointed rigid pavement survey data sheet (Figure A-9). One data sheet is used for each sample unit. A sketch is made of the sample unit, using the dots as joint intersections. The appropriate number code for each distress found in the slab is placed in the square representing the slab. The letters L (low), M (medium), or H (high) are included along with the distress number code to indicate the severity level of the distress. For example, 15L indicates that low severity corner spalling exists in the slab.

Refer to Appendix B for aid in identification of distresses and their severity levels. Follow these guidelines very closely.

Space is provided on the jointed rigid pavement survey data sheet for summarizing the distresses and computing the PCI for the sample unit. Summarize the distress type numbers and their severity levels and the number of slabs in the sample unit containing each type and level. Calculate the percentage of the total number of slabs in the sample unit containing each distress type and severity level. Using Figures A-10 through A-24, determine the deduct value for each distress type and severity level. Sum the deduct values to obtain the deduct total.

Noting how many individual deduct values are greater than 5, consult Figure A-25 to obtain the CDV. The PCI is then calculated and the rating (from Figure A-26) is entered on the jointed rigid pavement survey data sheet (Figure A-9). If the CDV for a sample unit is less than the highest individual distress deduct value, the highest value should be used in determining the PCI.

The PCI's for all sample units are compiled into a feature summary, as shown in Figure A-27. The overall condition rating of the feature is determined by using the mean PCI and Figure A-26.

DETAILED PROCEDURE FOR FLEXIBLE PAVEMENT

Each sample unit, or those selected by the sampling procedure, in the feature is inspected. The distress inspection is conducted by walking over the sample unit, measuring the distress type and severity according to Appendix B, and recording the data on the flexible pavement survey data sheet (Figure A-28). One data sheet is used for each sample unit. A hand odometer is very helpful for measuring distress. A 10-ft straightedge and a 12-in. scale must be available for measuring the depths of ruts or depressions. Each column on the data sheet is used to represent a distress type, and the amount and severity of each distress located are listed in the column. For example, distress No. 5 (depression) is recorded as 6 × 4L, which indicates that the depression is 6 by 4 ft and of low severity. Distress type No. 8 (longitudinal and

transverse cracking) is measured in linear feet, thus 10L indicates 10 ft of light cracking. This format is very convenient for recording data in the field.

Each distress type and severity level are summed either in square feet or linear feet, depending on the type of distress. The total units, either in square feet or linear feet, for each distress type and severity level are divided by the area of the sample unit to obtain the percent density. Using Figures A-29 through A-44, determine the deduct value for each distress type and severity level. Sum the deduct values to obtain the deduct total.

Noting how many individual deduct values are greater than 5, use Figure A-45 to obtain the CDV. The PCI is then calculated, and the rating (from Figure A-26) is entered on the flexible pavement survey data sheet. If the CDV for a sample unit is less than the highest individual distress deduct value, the highest value should be used in determining the PCI.

The PCI's for each sample unit are compiled into a feature summary, as shown in Figure A-46. The mean PCI for the feature is determined by averaging the PCI's from each sample unit. The overall condition rating of the feature is determined by use of the mean PCI and Figure A-26.

REPORTING CONDITION SURVEY RESULTS

The format for reporting the findings of the airport condition survey may be informal, designed to preclude the necessity of extensive drafting and typing. The pavement distress data and PCI computations can be presented as directly obtained from the survey data sheets and computations. The basic airport data collected will primarily reflect changes in airport pavement systems that have occurred since the last condition survey report. Reports should be prepared by the airport engineer on a recurring cycle at intervals designed to reflect gradual changes in pavement surface conditions. Reports should include, but not be limited to, the following:

a. Design pavement structure data. A form, such as Figure A-1, to include the history of all airport pavements, from original construction to the most recent changes and additions.

b. Pavement structural evaluation summary. If available, a summary of the last structural evaluation data (see Figure A-2).

c. Pavement maintenance record. When, where, and what type of maintenance has been performed (see Figure A-3).

d. Aircraft traffic data survey. Types of aircraft, typical gross loads, and airport facilities most likely used by the aircraft; also, the frequency of operations (see Figure A-4).

e. Plans and cross sections.

(1) Airport layout plan. The airport layout plan should depict airport pavements existing at the time of the condition survey. All airport facilities should be delineated and identified.

(2) Condition rating. An airport layout plan keyed to indicate the narrative condition rating of each feature. The feature PCI's should be indicated, possibly in tabular form.

(3) Drainage. Existing problem areas should be identified. Surface and subsurface drainage should be shown in plan and profile for all areas near to and intersecting with airport pavements.

f. Narrative. A narrative consisting of a written account of the visual condition of each feature. The purposes of the narrative are:

(1) To briefly describe the general condition of the pavement facilities.

(2) To describe operational conditions and problems.

(3) To describe the condition of other airport facilities found near the load-bearing pavements such as runway shoulders and overrun areas.

g. Photographs. Photographs showing typical or specific pavement conditions. An aerial photograph, current within 3 years, is desirable.

____________ AIRPORT

DESIGN PAVEMENT STRUCTURE DATA REVISED: __________

FACILITY: ____________ LOCATION, OR SECTION DESIGNATION FROM LAYOUT: ____________

CONSTRUCTION DATE	DESIGNED BY	PAVEMENT SURFACE TYPE/THICKNESS/STRENGTH	BASE TYPE/THICKNESS/STRENGTH	SUBBASE TYPE/THICKNESS/STRENGTH	SUBGRADE TYPE/STRENGTH

Figure A-1. Design pavement structure data

______________ AIRPORT

PAVEMENT STRUCTURAL EVALUATION SUMMARY

FACILITY	LOCATION	DATE OF EVALUATION	TYPE OF EVALUATION	EVALUATED BY	ALLOWABLE LOAD (AIRCRAFT, LOAD, DEPARTURES)	THICKNESS AND TYPE OF OVERLAY RECOMMENDED

Figure A-2. Pavement structural evaluation summary

________________ AIRPORT

CHRONOLOGICAL PAVEMENT MAINTENANCE RECORD

FACILITY	LOCATION	DATE PERFORMED	PERFORMED BY	TYPE MAINTENANCE	REASON FOR MAINTENANCE

Figure A-3. Pavement maintenance record

________________ AIRPORT

TRAFFIC DATA SURVEY REVISED: __________

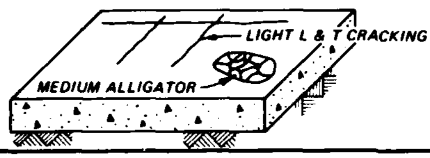
TYPE OF OPERATION	AIRCRAFT OPERATOR	TYPE AIRCRAFT	FACILITY MOST FREQUENTLY USED			TYPICAL GROSS WEIGHT	DEPARTURES PER DAY
			RUNWAY	TAXIWAY	APRON		
AIR CARRIER							
COMMUTER							
CARGO							
MILITARY							

Figure A-4. Traffic data survey

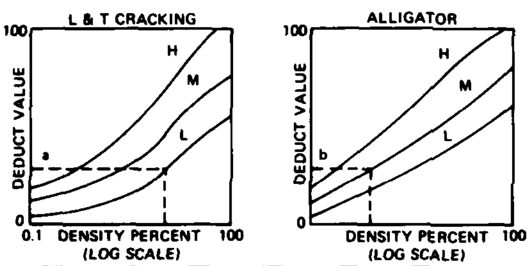
STEP 1. DIVIDE PAVEMENTS INTO FEATURES.

STEP 2. DIVIDE PAVEMENT FEATURE INTO SAMPLE UNITS.

STEP 3. INSPECT SAMPLE UNITS; DETERMINE DISTRESS TYPES AND SEVERITY LEVELS AND MEASURE DENSITY.

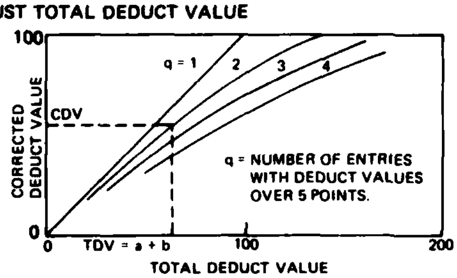


STEP 4. DETERMINE DEDUCT VALUES



STEP 5. COMPUTE TOTAL DEDUCT VALUE (TDV) a + b

STEP 6. ADJUST TOTAL DEDUCT VALUE



STEP 7. COMPUTE PAVEMENT CONDITION INDEX (PCI) = 100 - CDV FOR EACH SAMPLE UNIT INSPECTED.

STEP 8. COMPUTE PCI OF ENTIRE FEATURE (AVERAGE PCI'S OF SAMPLE UNITS).

STEP 9. DETERMINE PAVEMENT CONDITION RATING OF FEATURE.

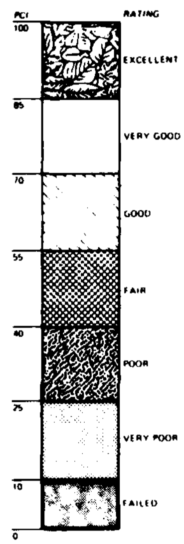


Figure A-5. Steps for determining PCI of a pavement feature

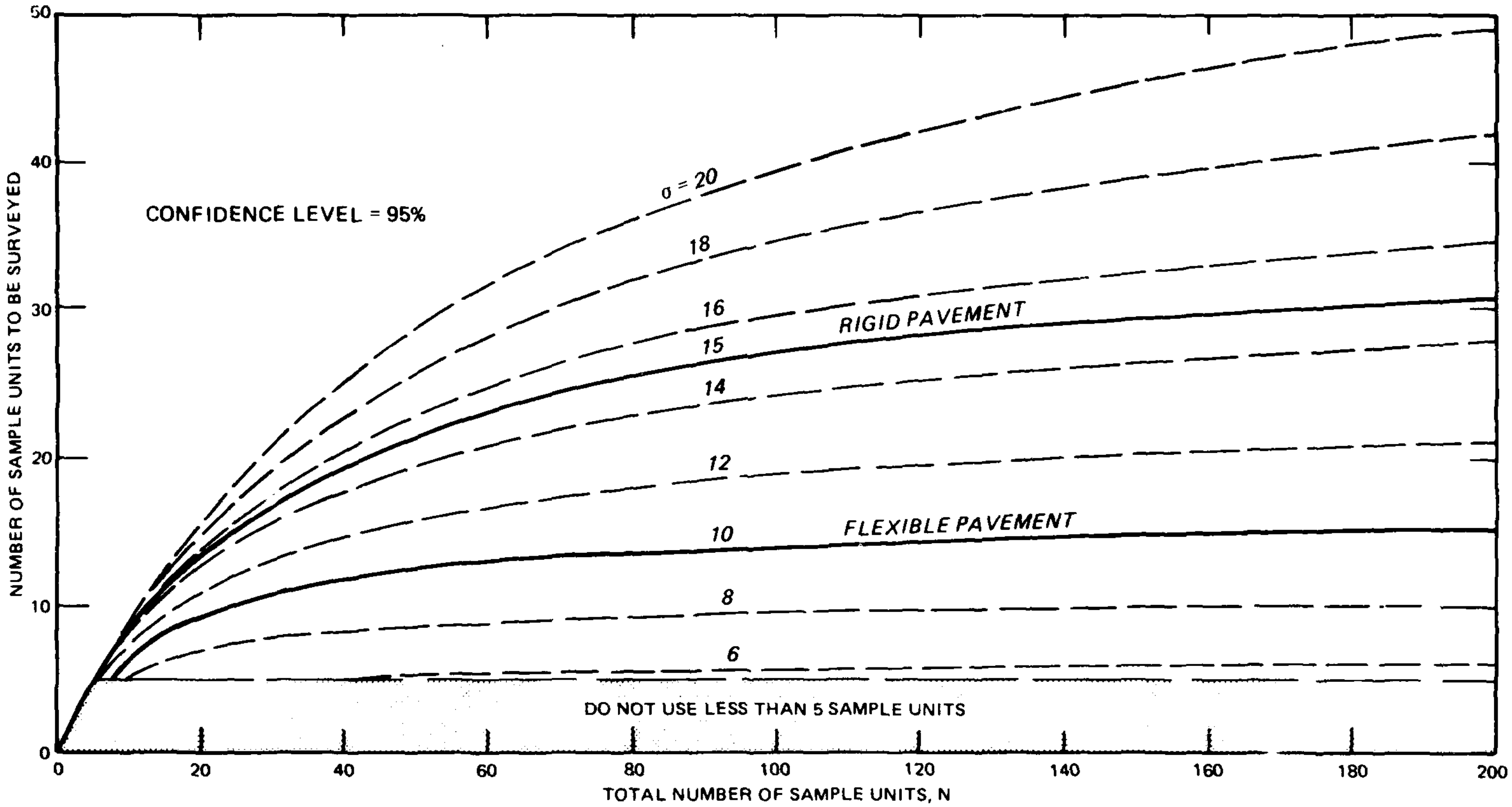


Figure A-6. Selection of minimum number of sample units

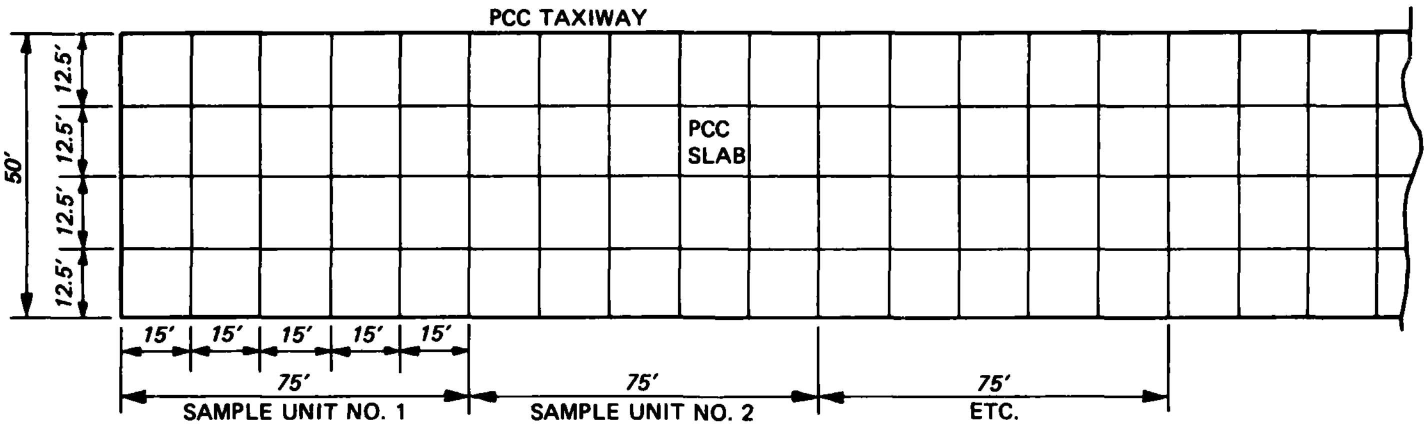
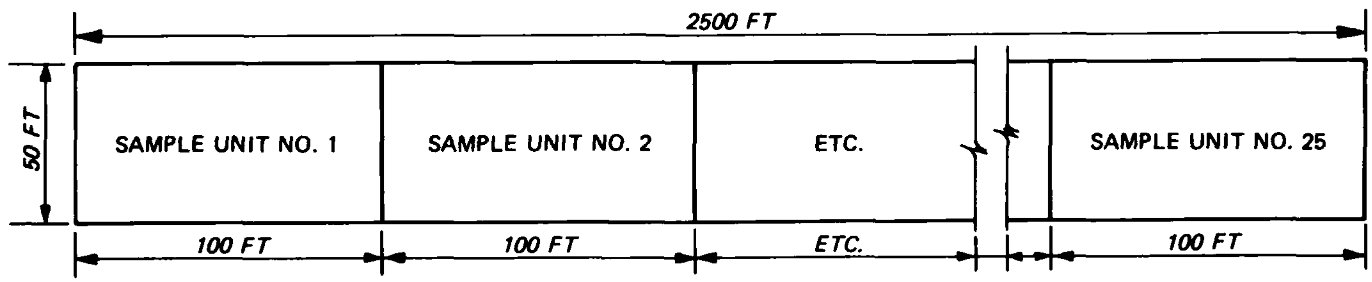


Figure A-7. Illustration of division of a jointed rigid pavement feature into sample units of 20 slabs

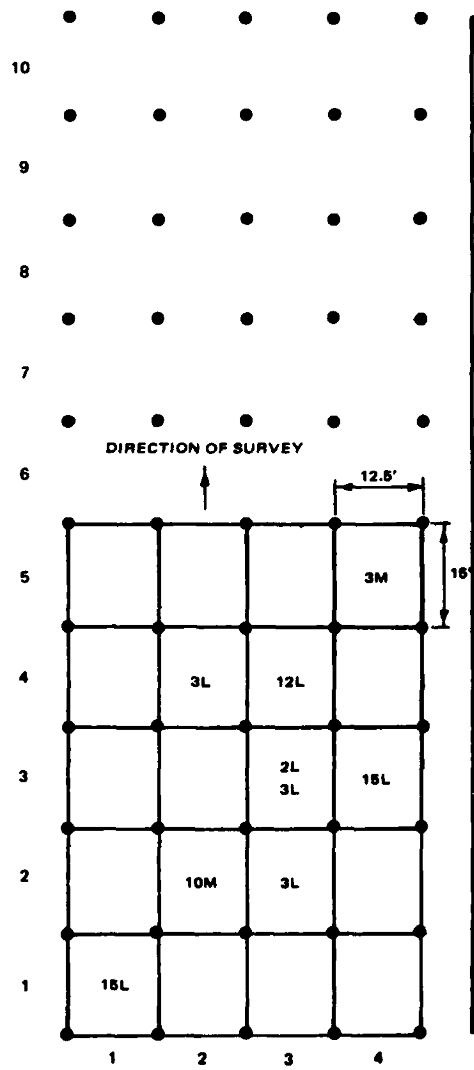


FEATURE DIMENSION = 50 X 2500 FT
SAMPLE UNIT = 50 X 100 FT
NUMBER OF SAMPLE UNITS = 25

Figure A-8. Example division of flexible pavement feature into sample units

JOINTED RIGID PAVEMENT
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

AIRPORT: WORLD INTERNATIONAL		DATE: 5/26/79
FACILITY: RWY 9-27	FEATURE: R3	SAMPLE UNIT: 12
SURVEYED BY: JH/DE		SLAB SIZE: 12.5 X 15 FT



DISTRESS TYPES

1. BLOW-UP
2. CORNER BREAK
3. LONGITUDINAL/ TRANSVERSE/ DIAGONAL CRACK
4. "D" CRACK
5. JOINT SEAL DAMAGE
6. PATCHING, <5 FT^2
7. PATCHING/ UTILITY CUT
8. POPOUTS
9. PUMPING
10. SCALING/MAP CRACK/CRAZING
11. SETTLEMENT/ FAULT
12. SHATTERED SLAB
13. SHRINKAGE CRACK
14. SPALLING -- JOINTS
15. SPALLING — CORNER

DIST. TYPE	SEV.	NO. SLABS	DENSITY %	DEDUCT VALUE
2	L	1	5	4
3	L	3	15	11
3	M	1	5	11
10	M	1	5	7
12	L	1	5	10
15	L	2	10	3
DEDUCT TOTAL				46
CORRECTED DEDUCT VALUE (CDV)				32

PCI = 100 – CDV = 68

RATING = GOOD

Figure A-9. Jointed rigid pavements - condition survey data sheet

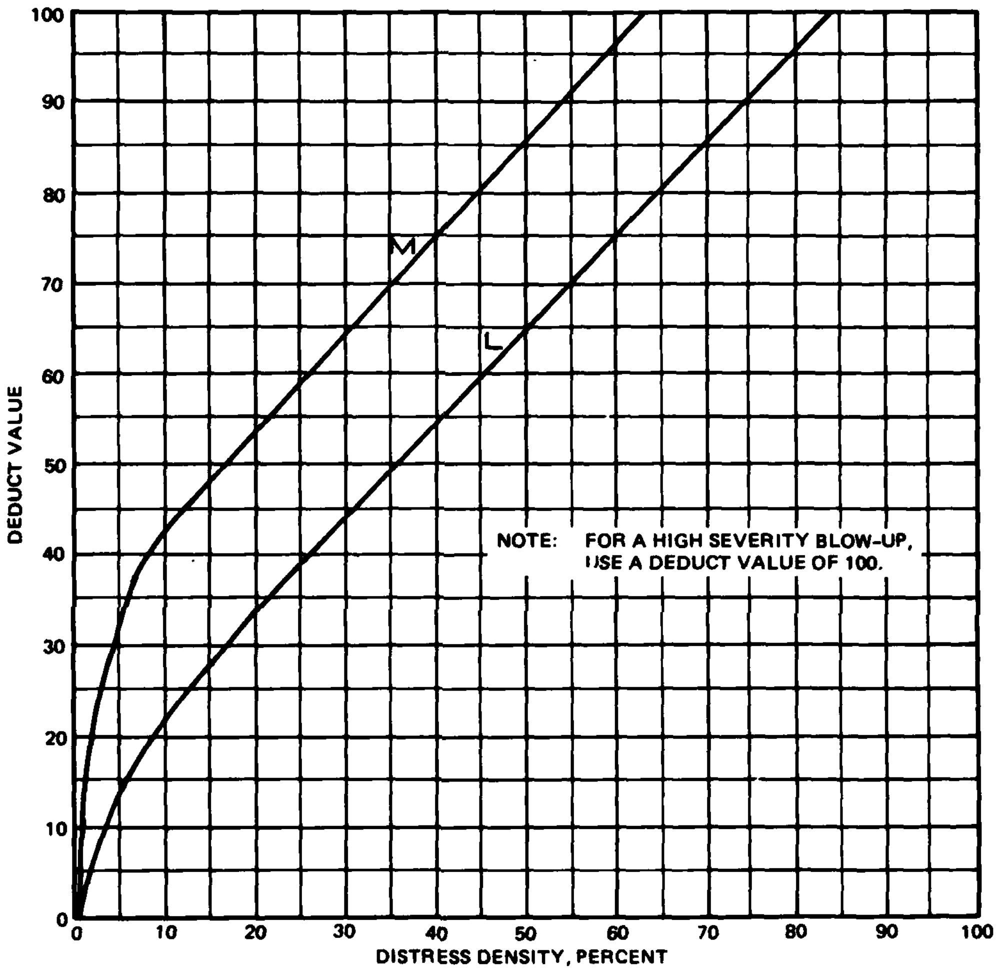


Figure A-10. Rigid pavement deduct values, distress 1, blowup

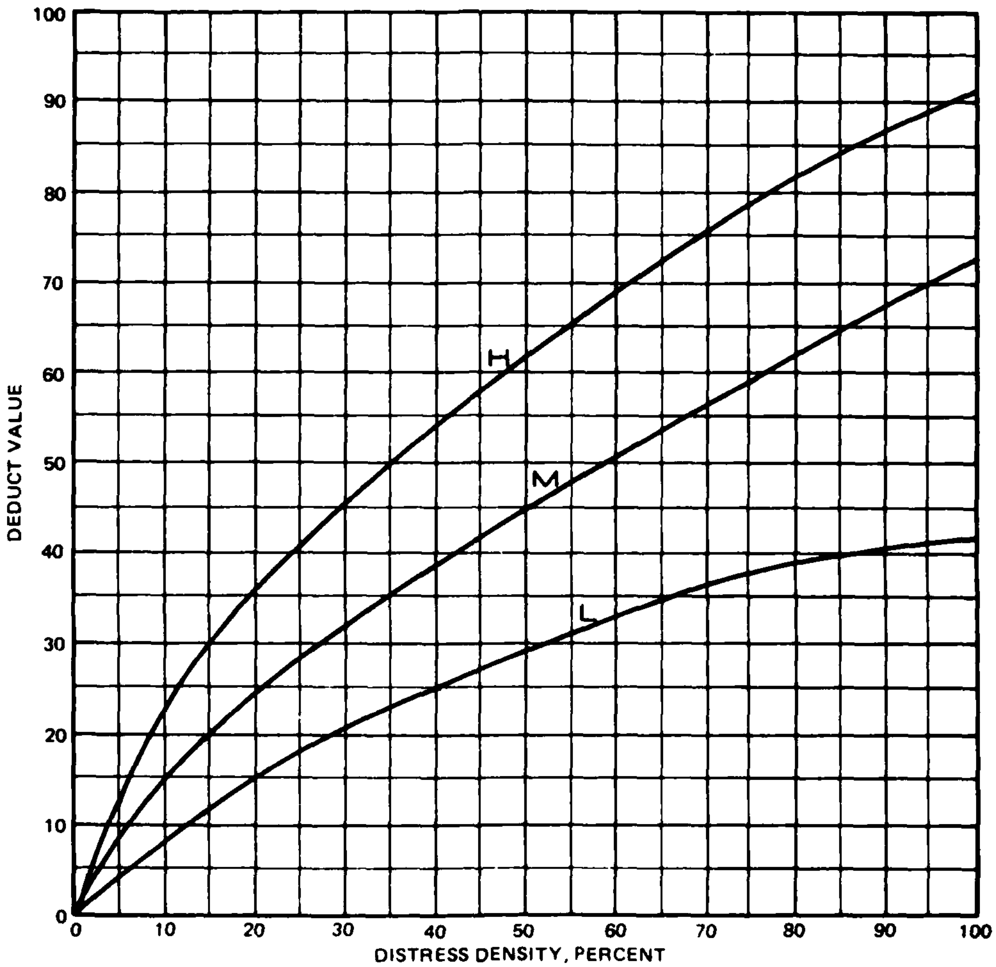


Figure A-11. Rigid pavement deduct values, distress 2, corner break

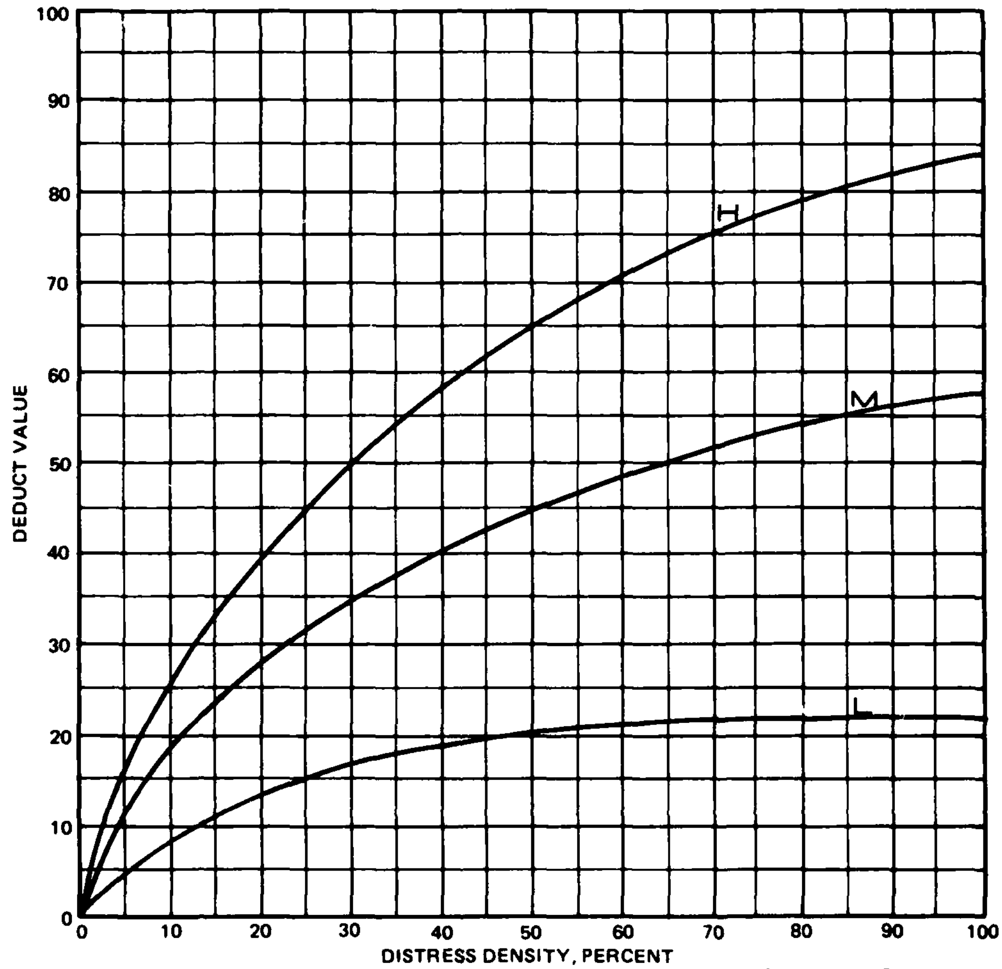


Figure A-12. Rigid pavement deduct values, distress 3, longitudinal/transverse/diagonal cracking

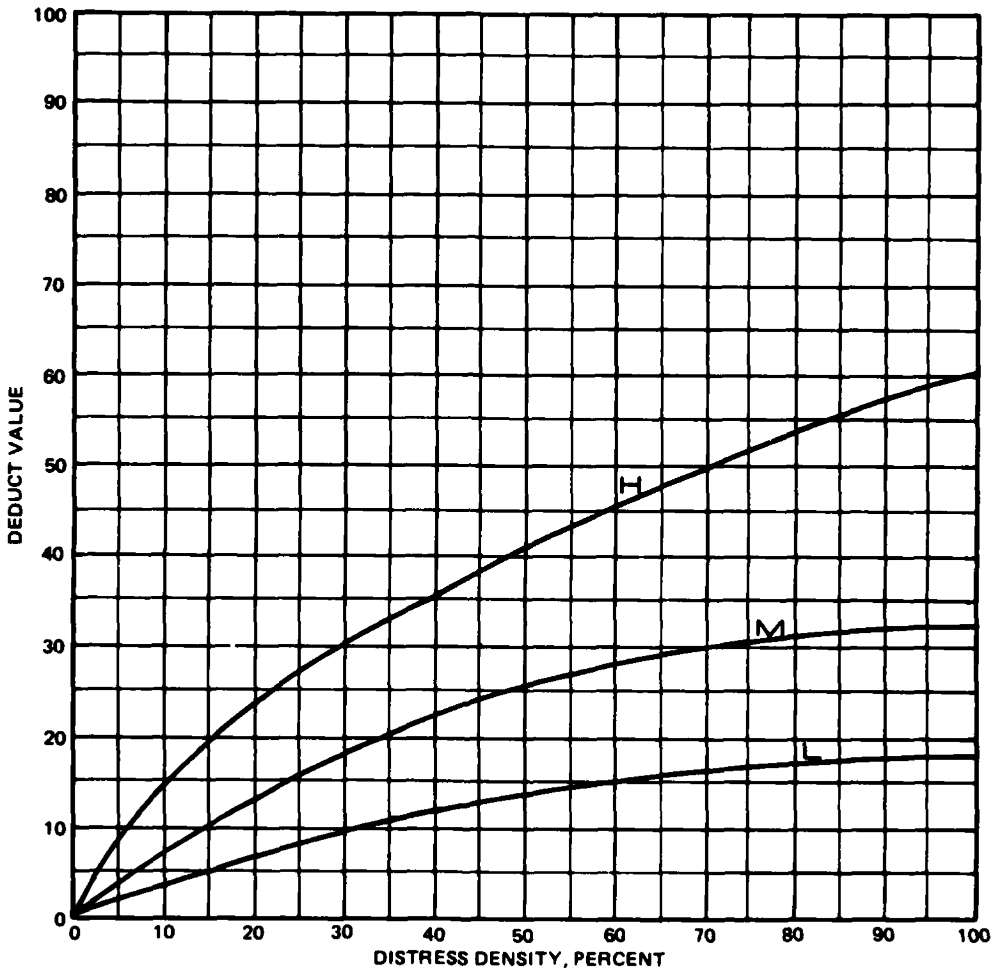


Figure A-13. Rigid pavement deduct values, distress 4, durability cracking

JOINT SEAL DAMAGE IS NOT RATED BY DENSITY. THE SEVERITY OF THE DISTRESS IS DETERMINED BY THE SEALANT'S OVERALL CONDITION FOR A PARTICULAR SECTION.

THE DEDUCT VALUES FOR THE THREE LEVELS OF SEVERITY ARE AS FOLLOWS:

1. HIGH SEVERITY - 12 POINTS
2. MEDIUM SEVERITY - 7 POINTS
3. LOW SEVERITY - 2 POINTS

Figure A-14. Rigid pavement deduct values, distress 5, joint seal damage

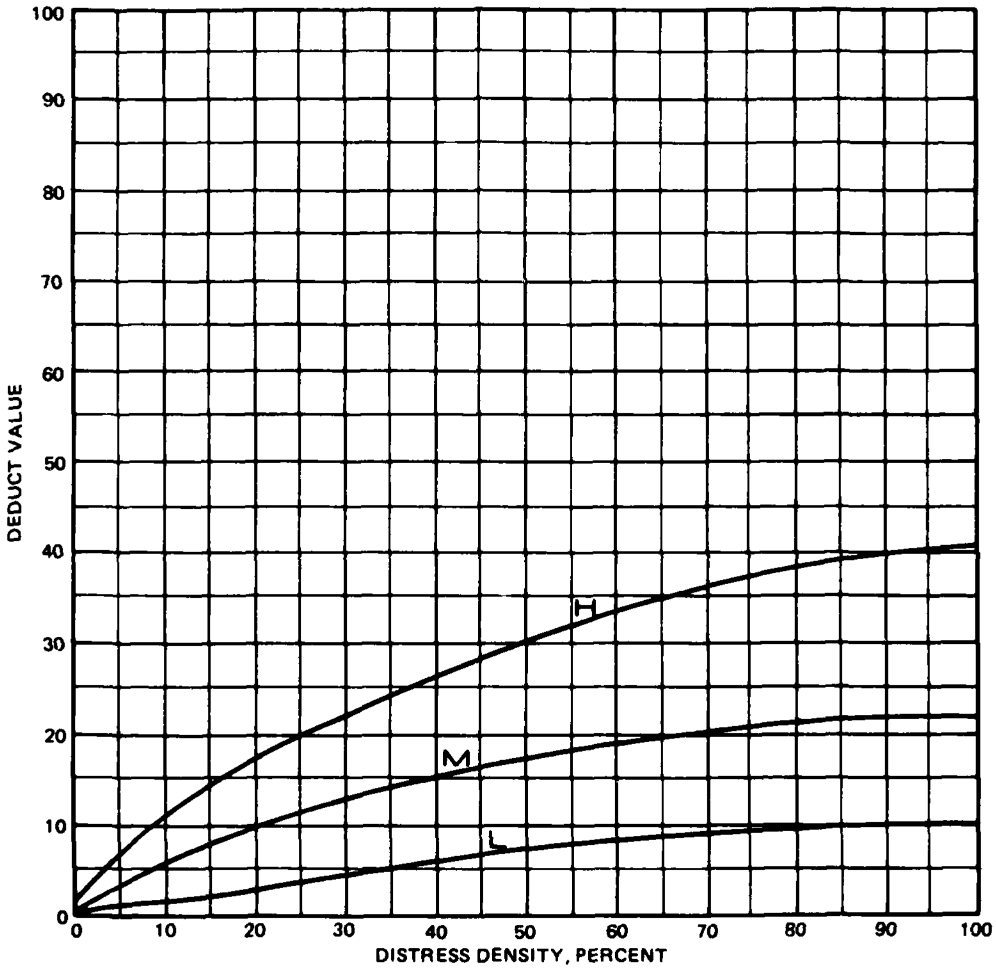


Figure A-15. Rigid pavement deduct values, distress 6, small patch

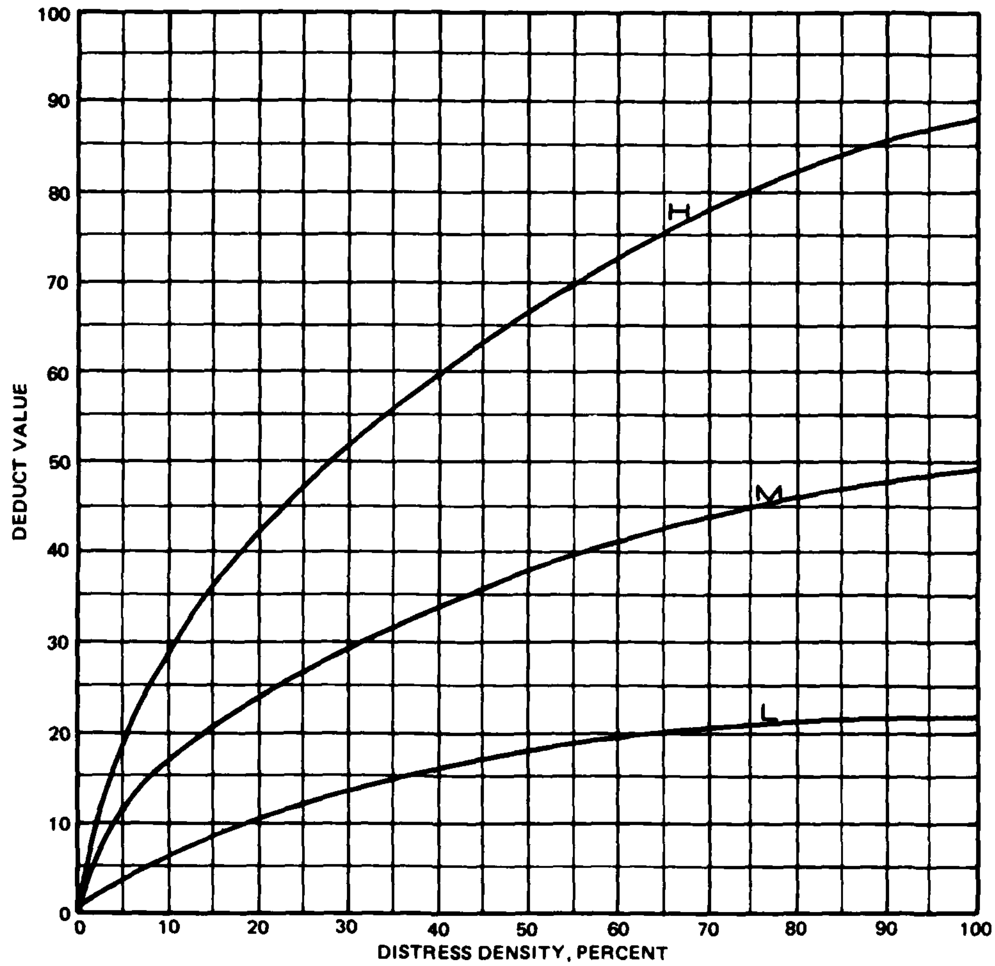


Figure A-16. Rigid pavement deduct values, distress 7, patching/utility cut defect

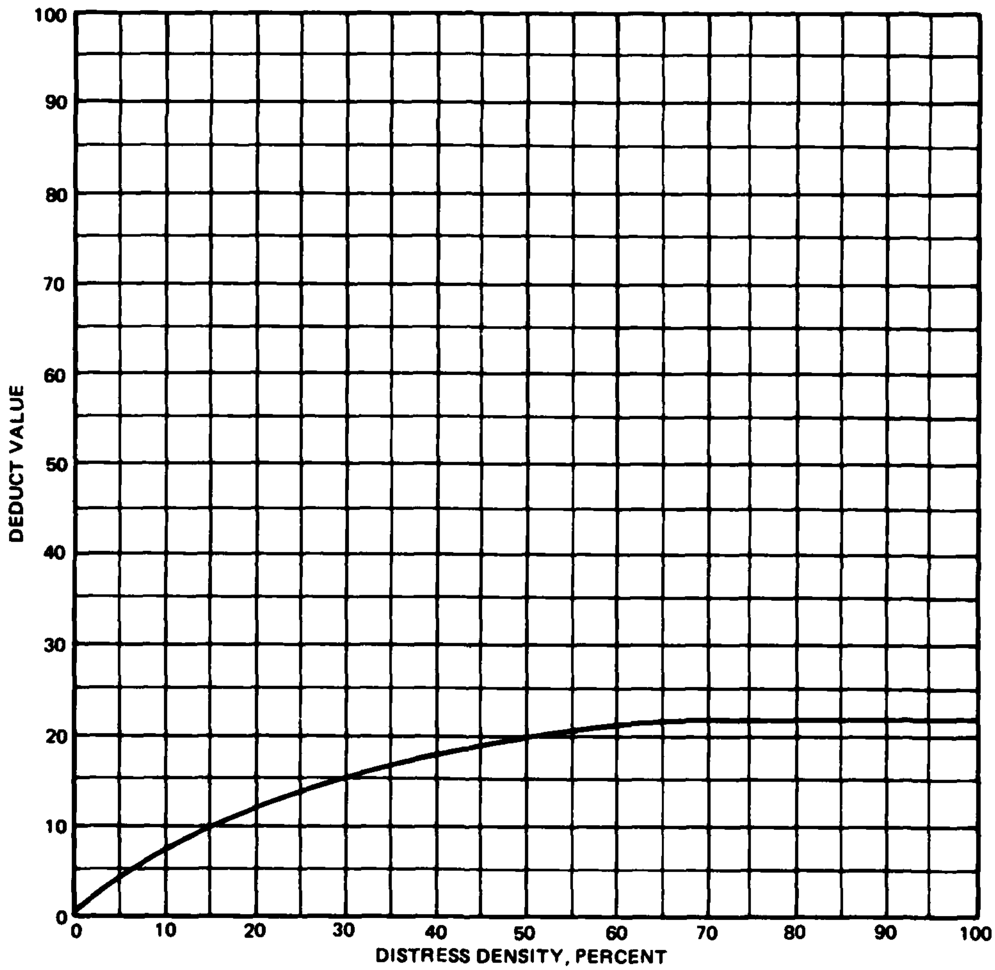


Figure A-17. Rigid pavement deduct values, distress 8, popouts

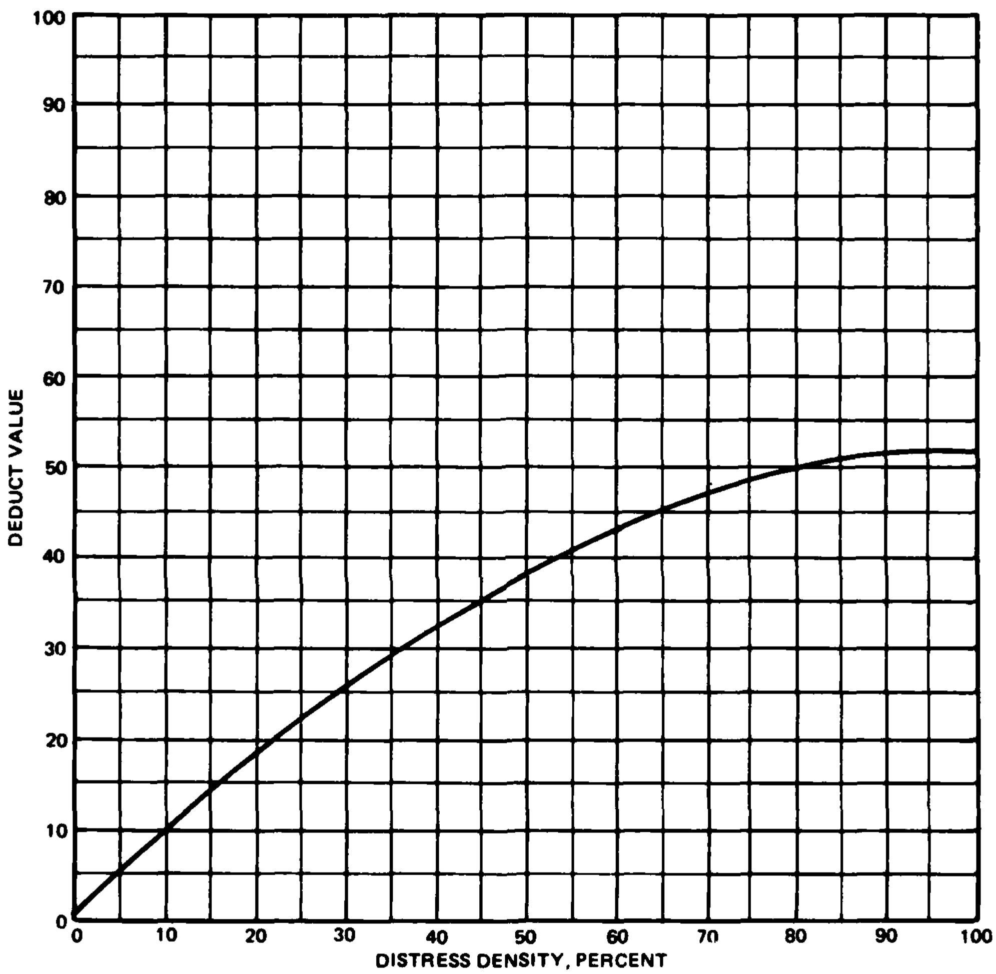


Figure A-18. Rigid pavement deduct values, distress 9, pumping

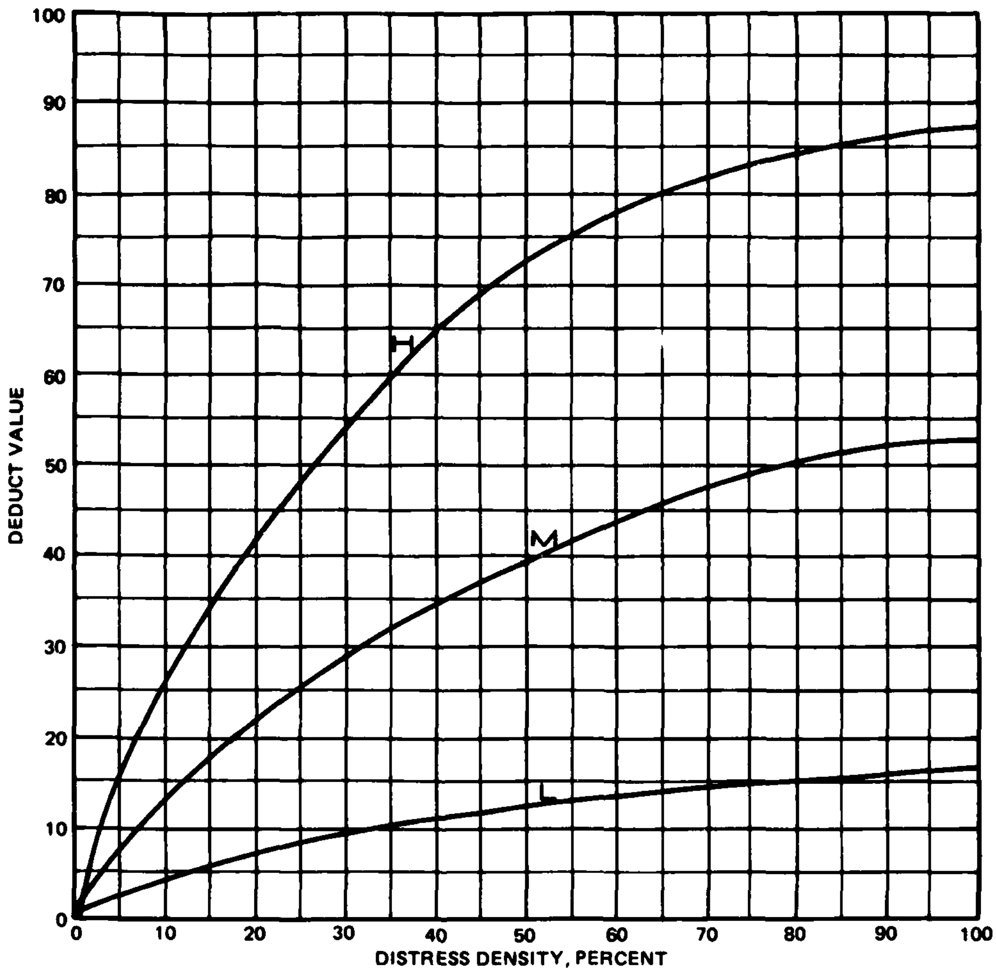


Figure A-19. Rigid pavement deduct values, distress 10, scaling

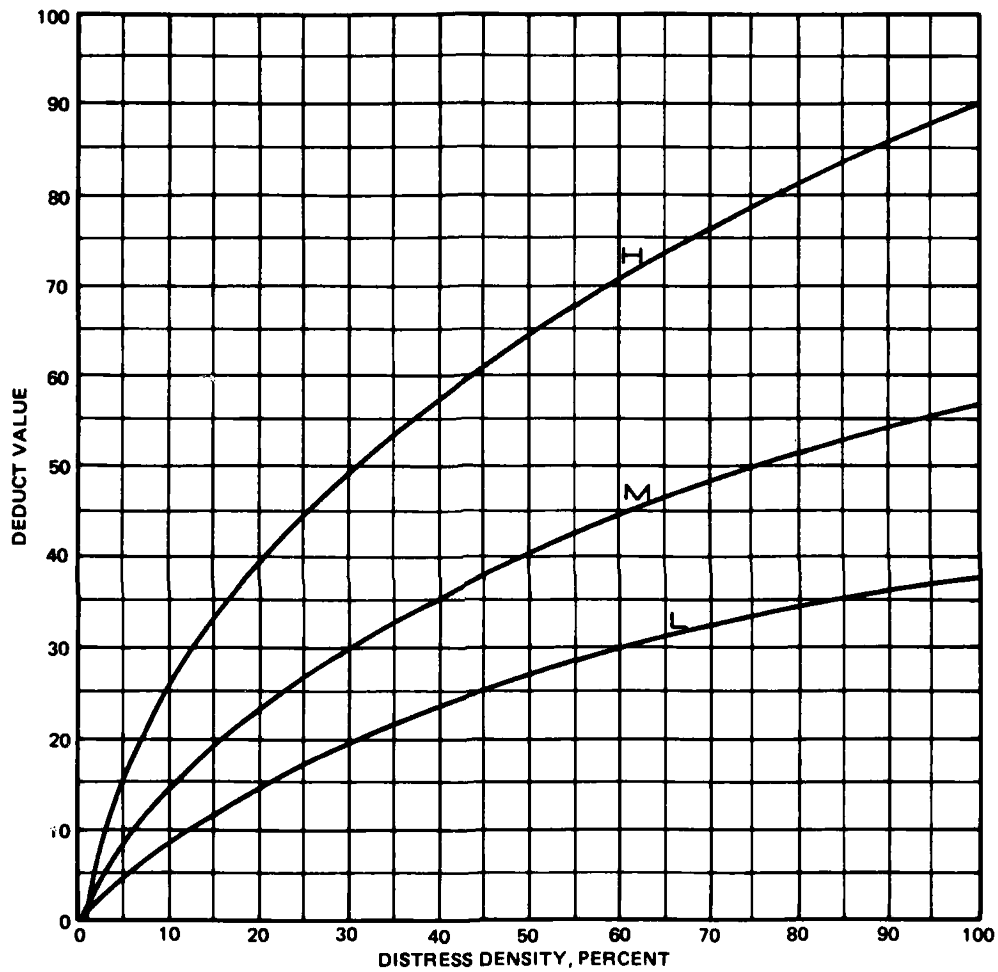


Figure A-20. Rigid pavement deduct values, distress 11, settlement

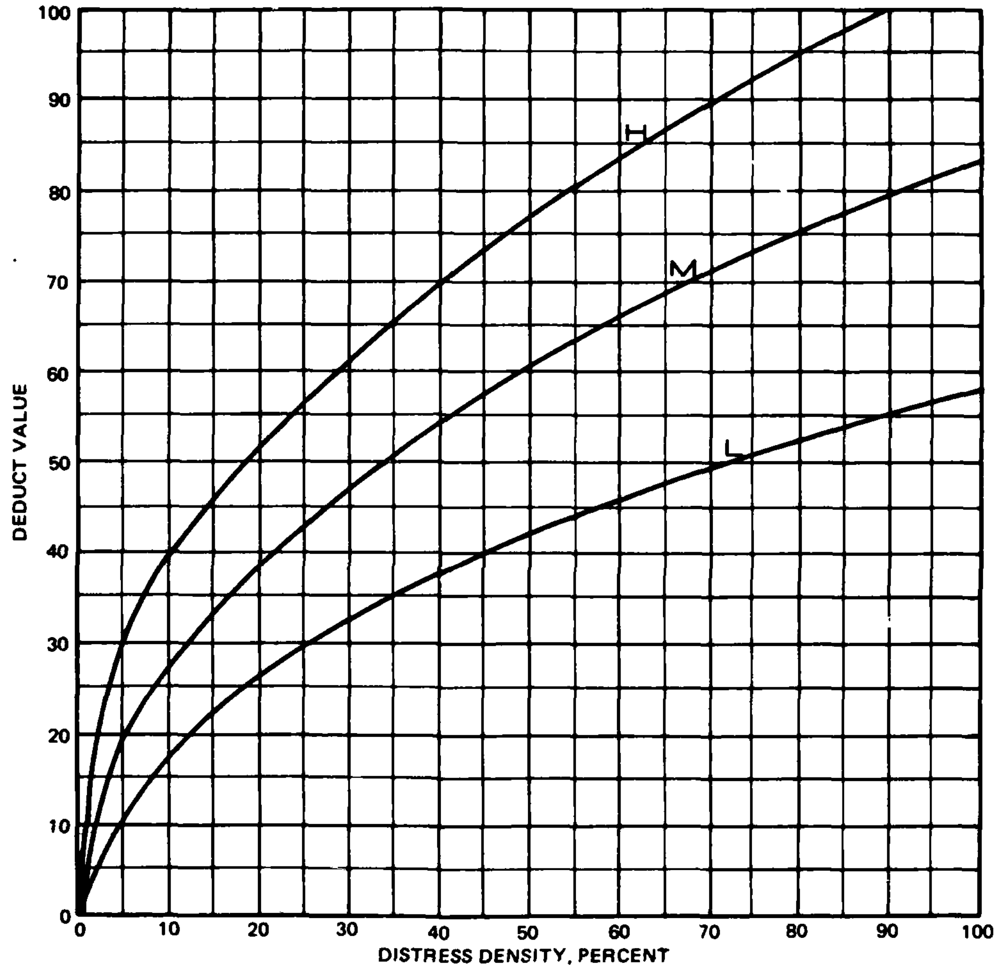


Figure A-21. Rigid pavement deduct values, distress 12, shattered slab

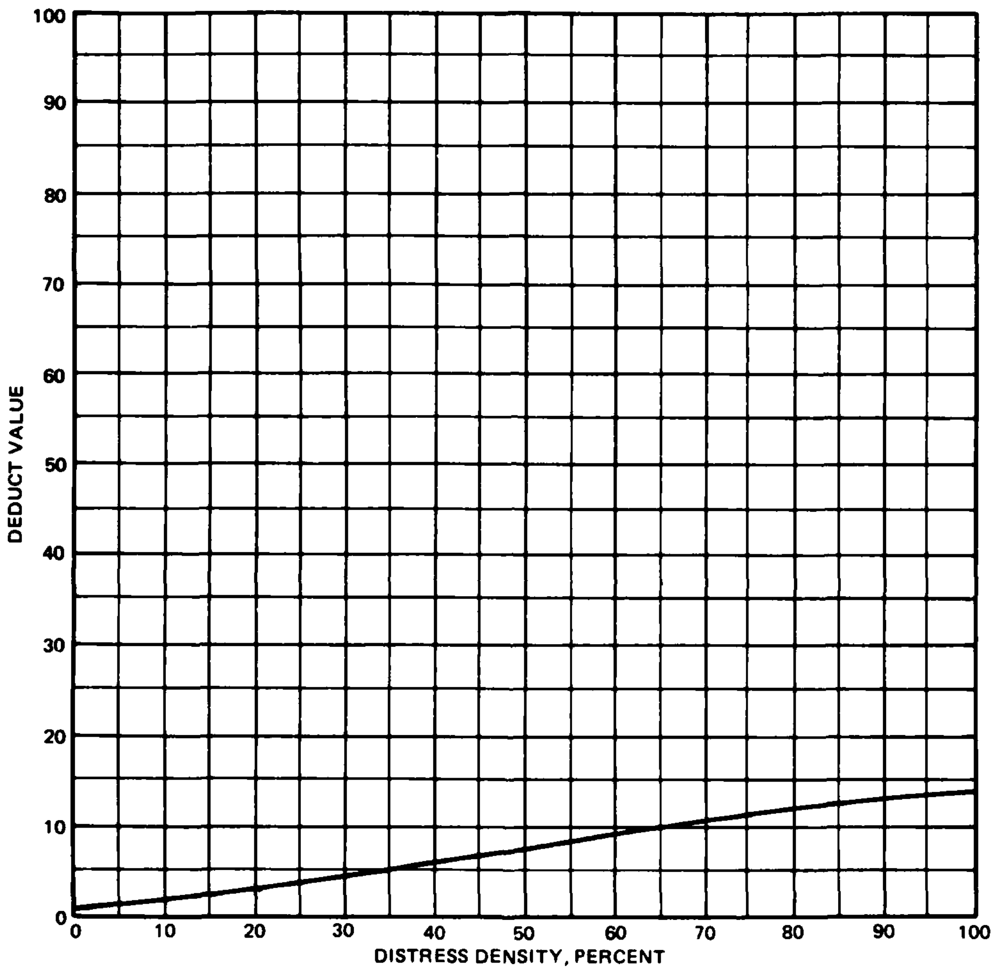


Figure A-22. Rigid pavement deduct values,
distress 13, shrinkage cracks

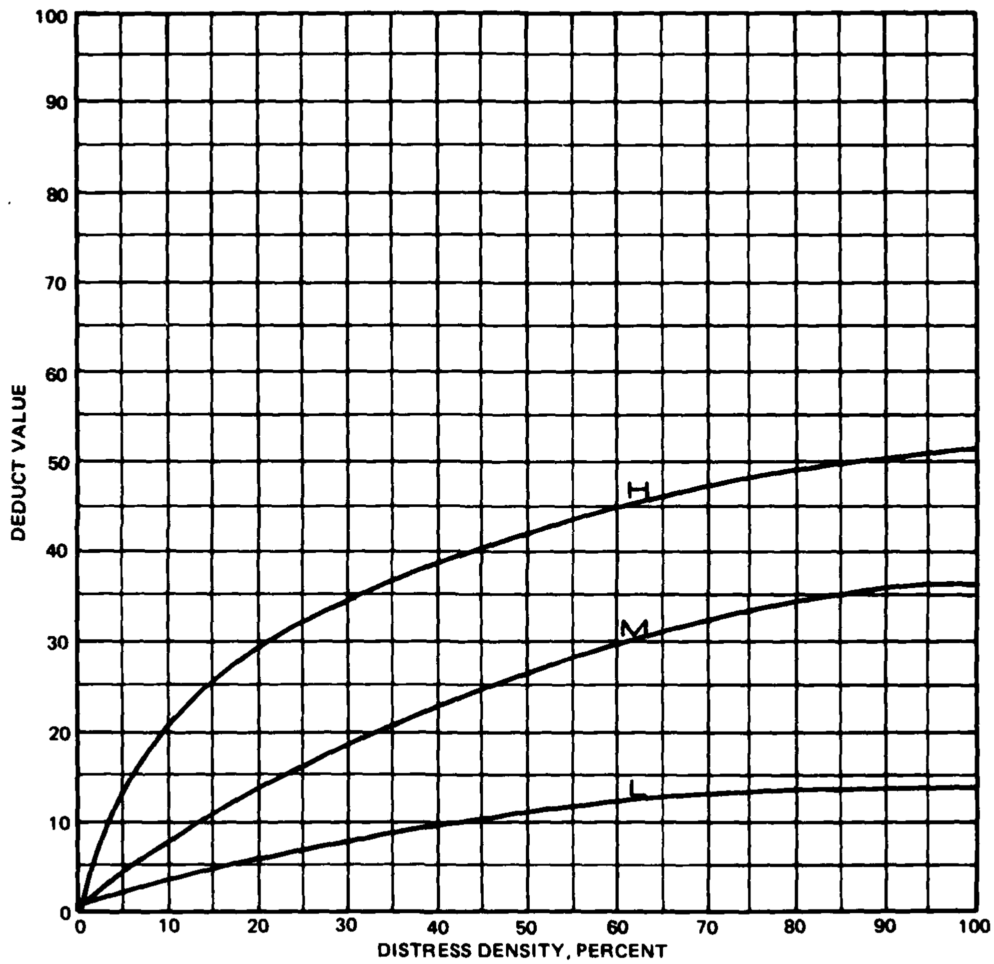


Figure A-23. Rigid pavement deduct values, distress 14, spalling along the joints

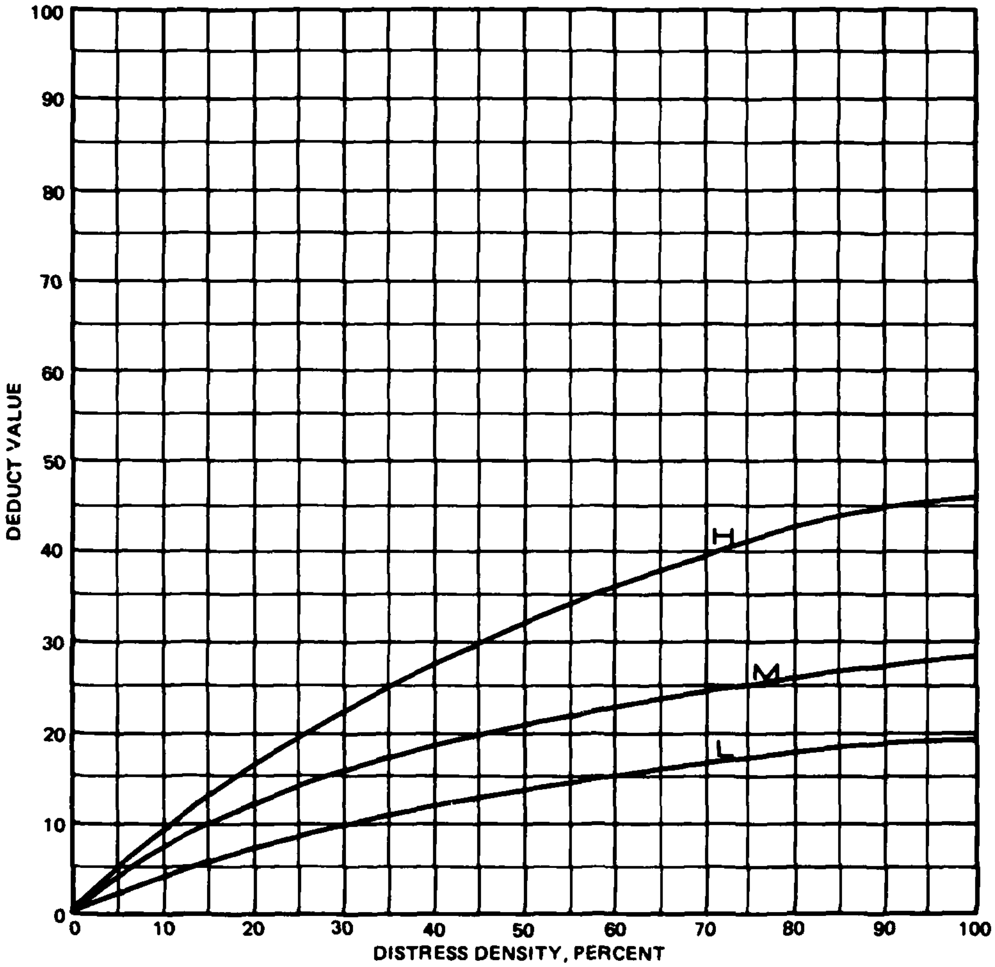


Figure A-24. Rigid pavement deduct values, distress 15, spalling corner

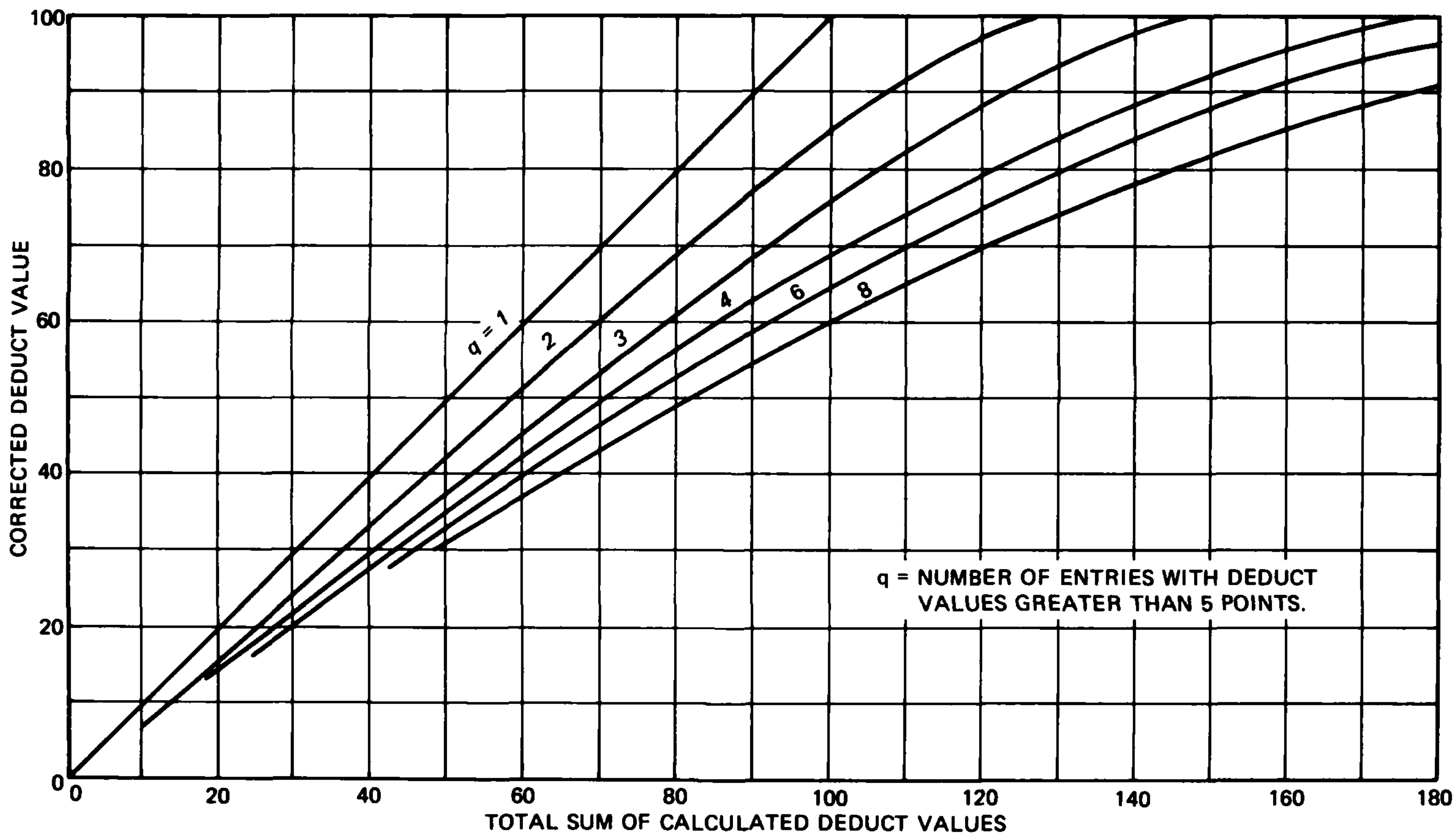


Figure A-25. Corrected deduct values for jointed rigid pavements

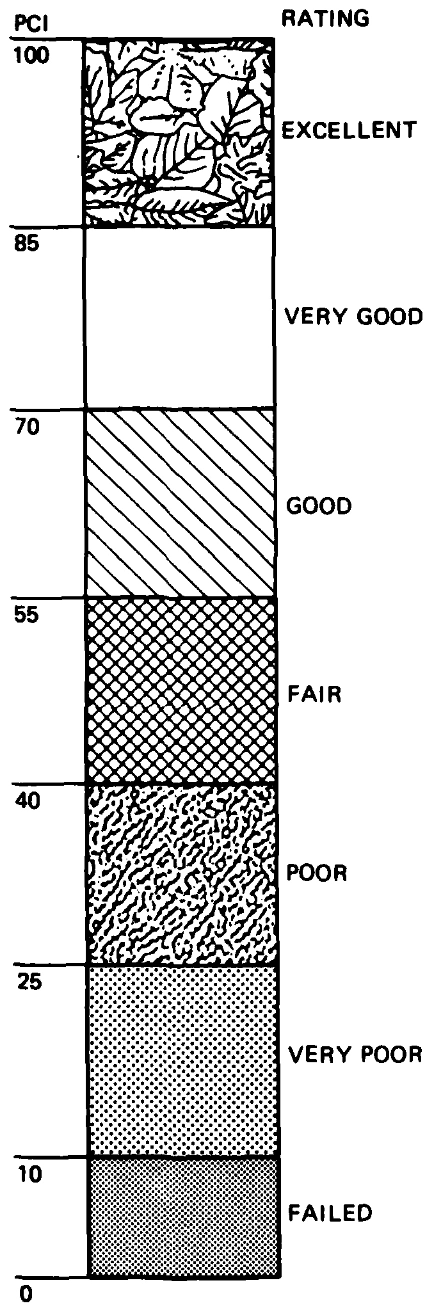


Figure A-26. Airport pavement condition index (PCI) and rating

Airport: World International

Airport Facility: Taxiway 1

Total No. of Sample Units: 5

Date of Survey: 15 March 1979

Sample Unit No.	No. of Slabs	Slab Size	PCI
1	20	12.5 x 15	68
2	20	12.5 x 15	64
3	20	12.5 x 15	64
4	20	12.5 x 15	74
5	20	12.5 x 15	28

Sample Unit No.	No. of Slabs	Slab Size	PCI

Average PCI for Feature: 62

Condition Rating: Good

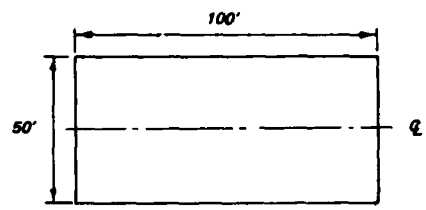
Figure A-27. Feature summary - jointed rigid pavement

FLEXIBLE PAVEMENT CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT		
AIRPORT WORLD INTERNATIONAL		DATE 5/26/79
FACILITY TXY E	FEATURE T-11	SAMPLE UNIT 4
SURVEYED BY JH/DE		AREA OF SAMPLE 5000 SQ FT

DISTRESS TYPES

1. ALLIGATOR CRACKING
2. BLEEDING
3. BLOCK CRACKING
4. CORRUGATION
5. DEPRESSION
6. JET BLAST
7. JT. REFLECTION (PCC)
8. LONG. & TRANS. CRACKING
9. OIL SPILLAGE
10. PATCHING
11. POLISHED AGGREGATE
12. RAVELING/WEATHERING
13. RUTTING
14. SHOVING FROM PCC
15. SLIPPAGE CRACKING
16. SWELL

SKETCH:



EXISTING DISTRESS TYPES

	1	5	8	12		
	4 X 4 M	6 X 4 L	10 L	3 X 10 M		
	2 X 3 L		5 L			
			15 L			
			5 M			
			10 L			
			5 M			
TOTAL SEVERITY L	6 SQ FT	24 SQ FT	40 FT			
TOTAL SEVERITY M	16 SQ FT		10 FT	30 SQ FT		
TOTAL SEVERITY H						

PCI CALCULATION

DISTRESS TYPE	SEVERITY	DENSITY %	DEDUCT VALUE
1	L	0.22	7
1	M	0.32	19
5	L	0.48	2
8	L	0.80	5
8	M	0.20	5
12	M	0.60	7
DEDUCT TOTAL			45
CORRECTED DEDUCT VALUE (CDV)			25

PCI = 100 – CDV = 75

RATING = VERY GOOD

Figure A-28. Flexible pavements - condition survey data sheet

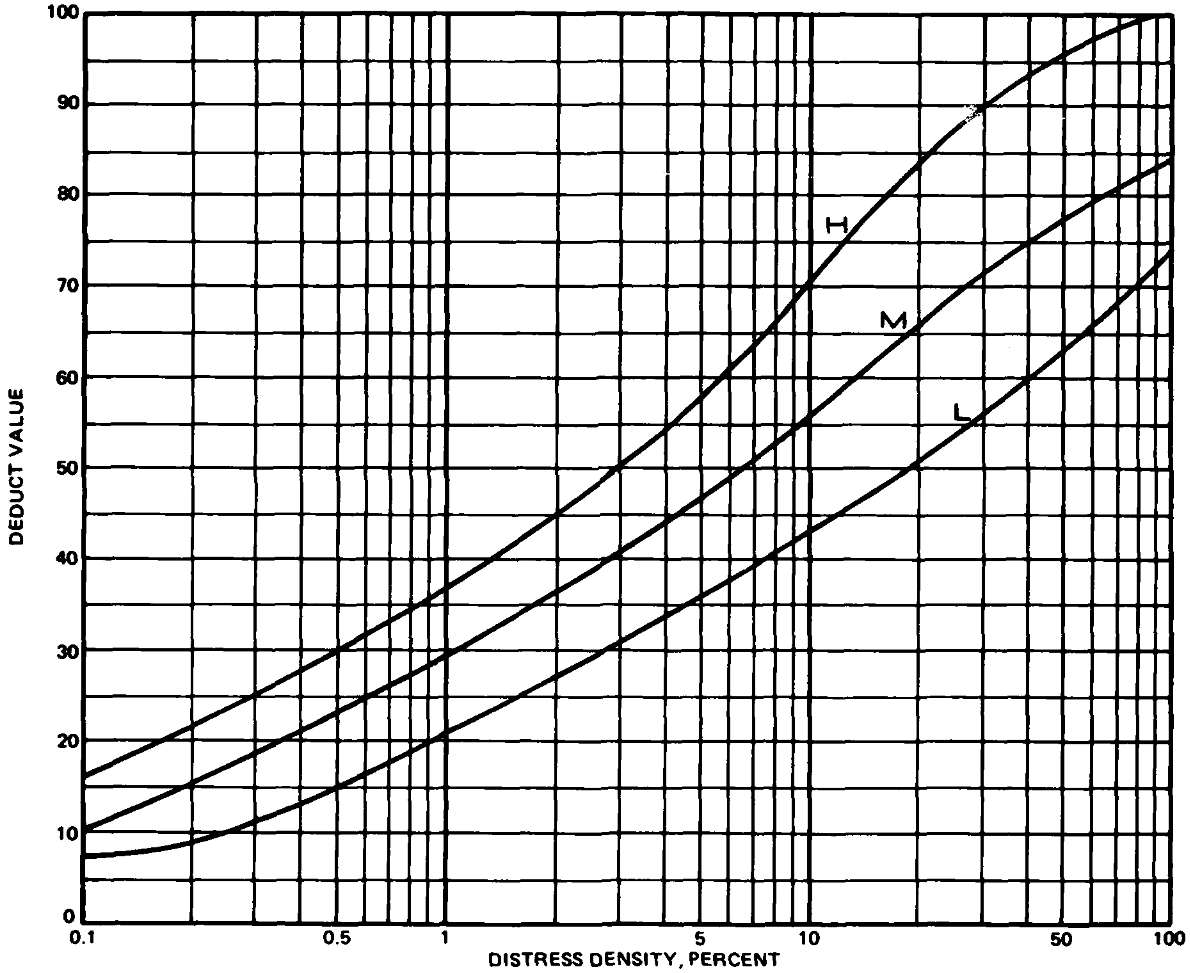


Figure A-29. Flexible pavement deduct values, distress 1, alligator cracking

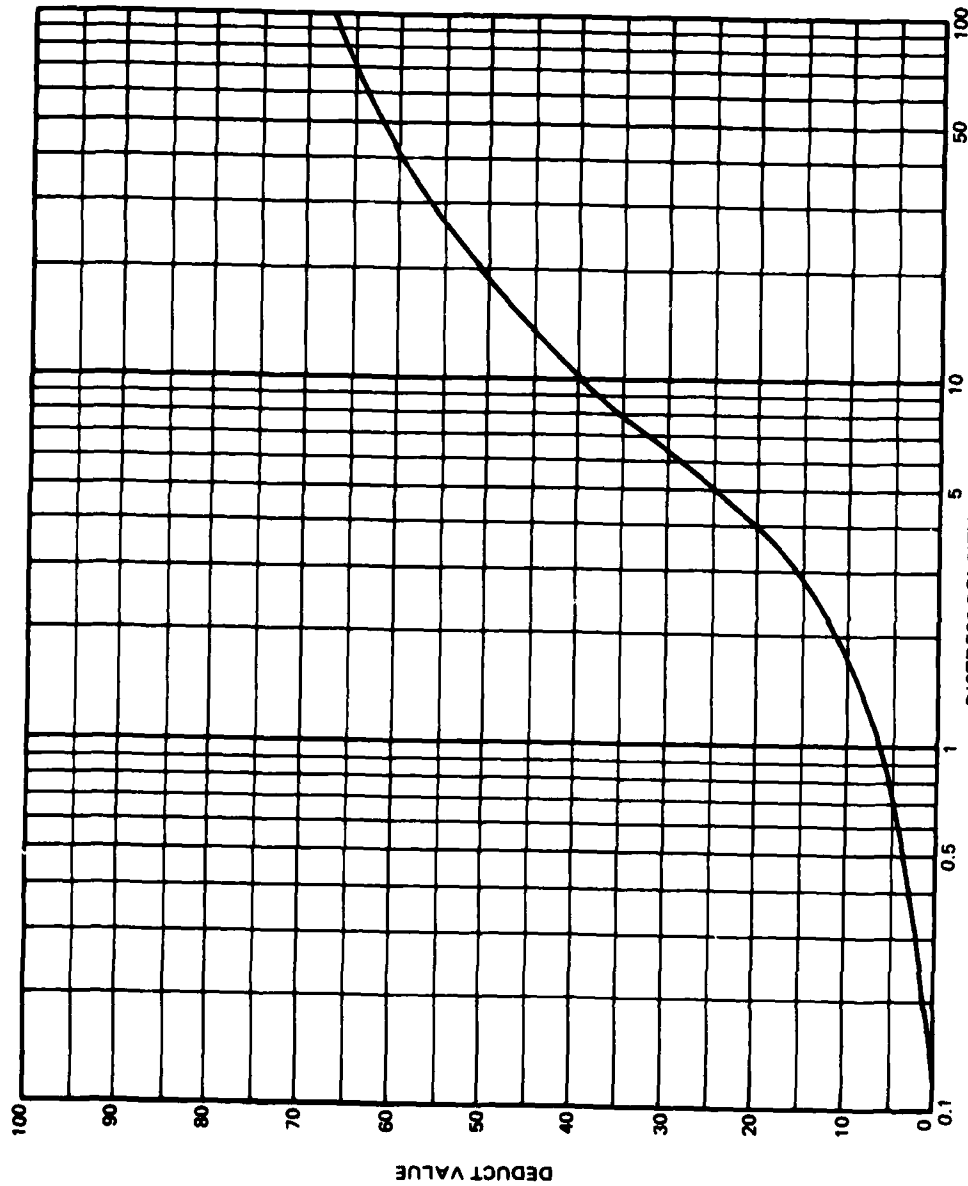


Figure A-30. Flexible pavement deduct values,
distress 2, bleeding

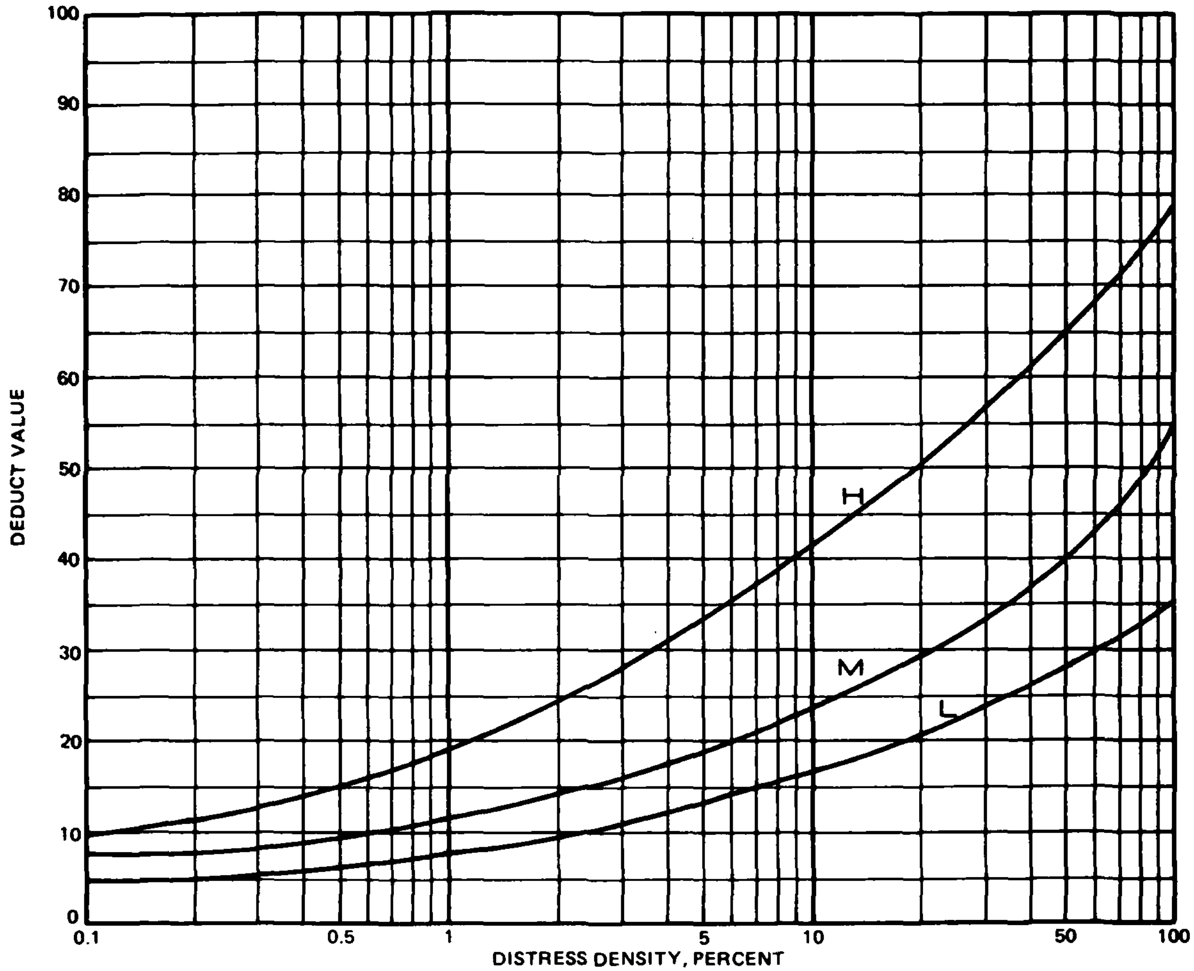


Figure A-31. Flexible pavement deduct values, distress 3, block cracking

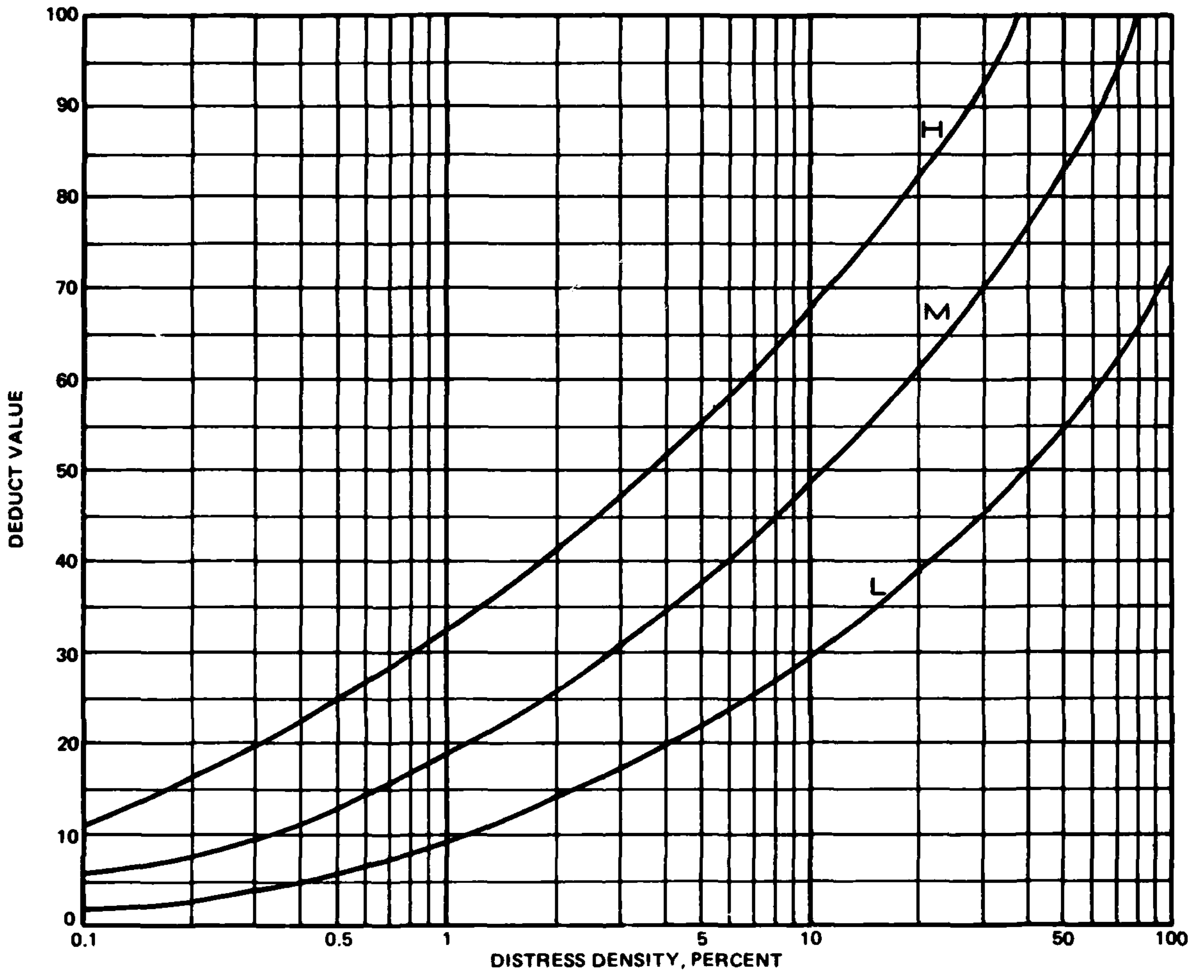


Figure A-32. Flexible pavement deduct values, distress 4, corrugation

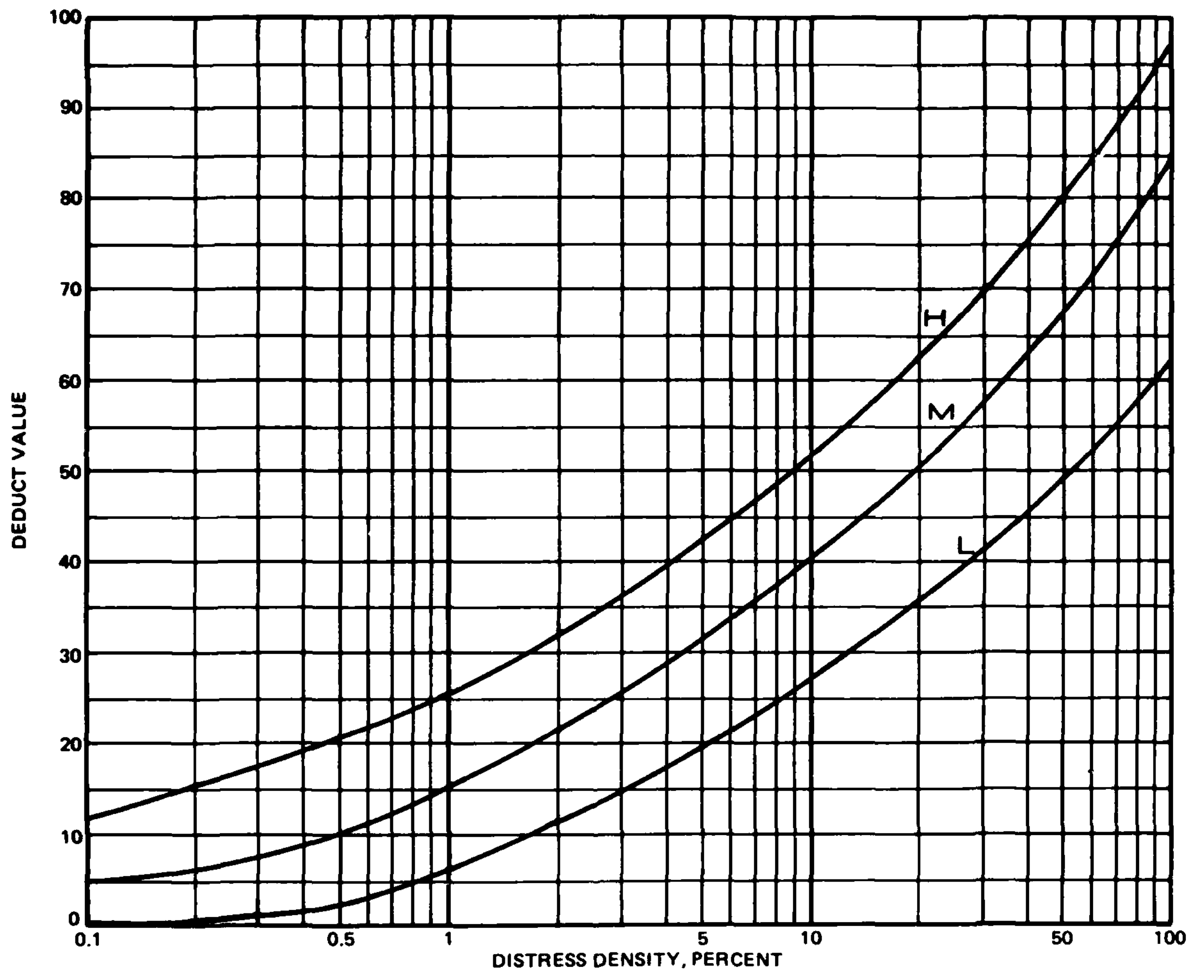


Figure A-33. Flexible pavement deduct values, distress 5, depression

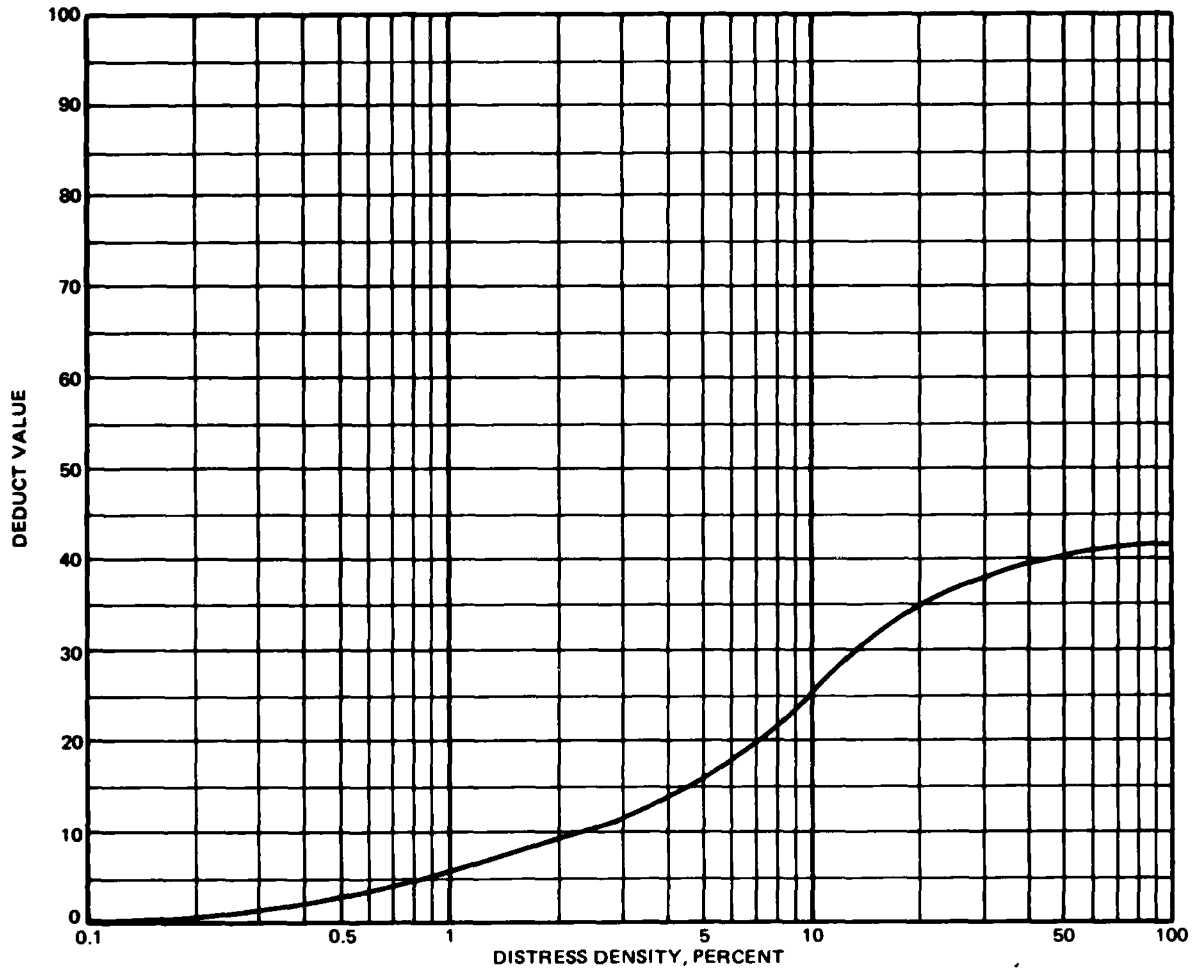


Figure A-34. Flexible pavement deduct values, distress 6, jet blast erosion

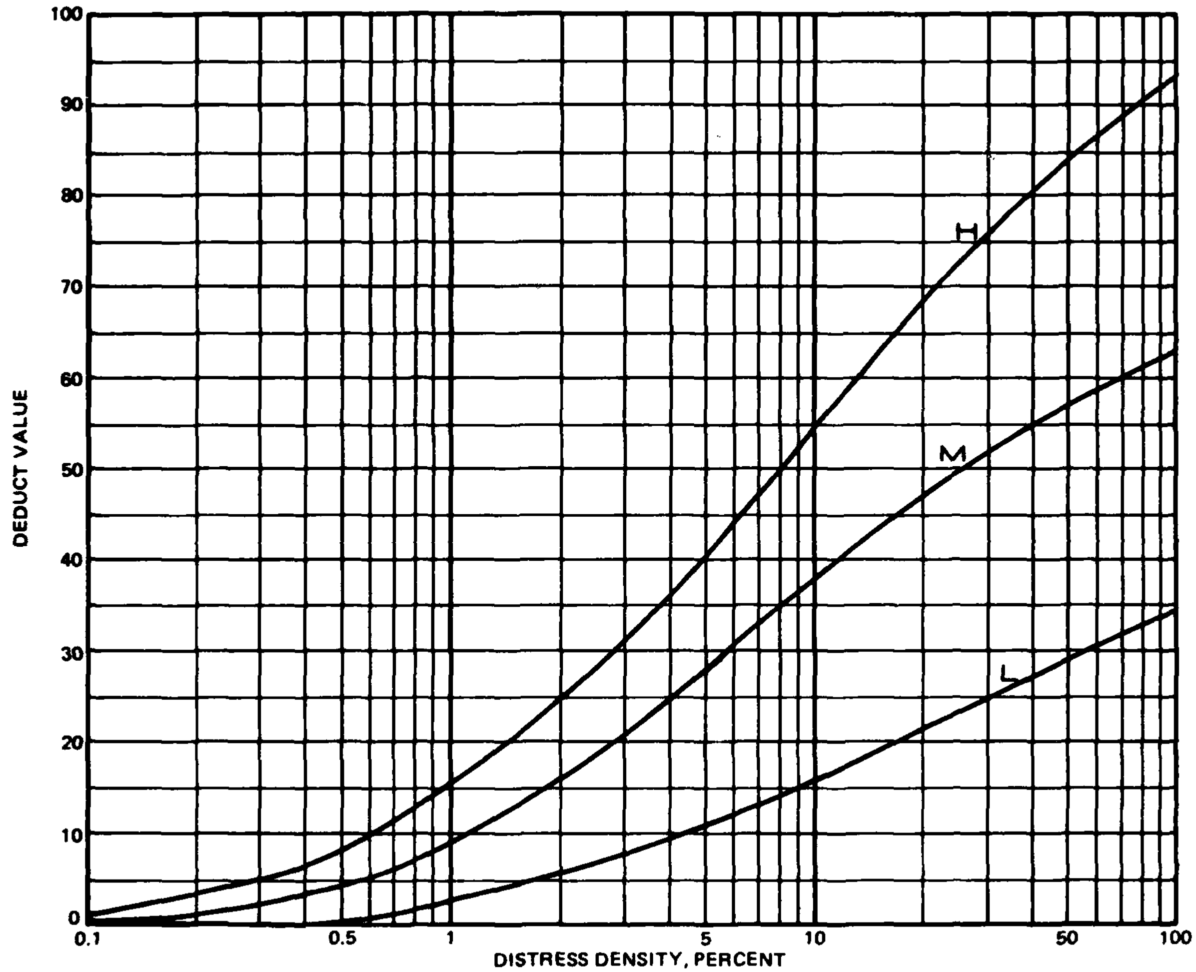


Figure A-35. Flexible pavement deduct values,
distress 7, joint reflection cracking

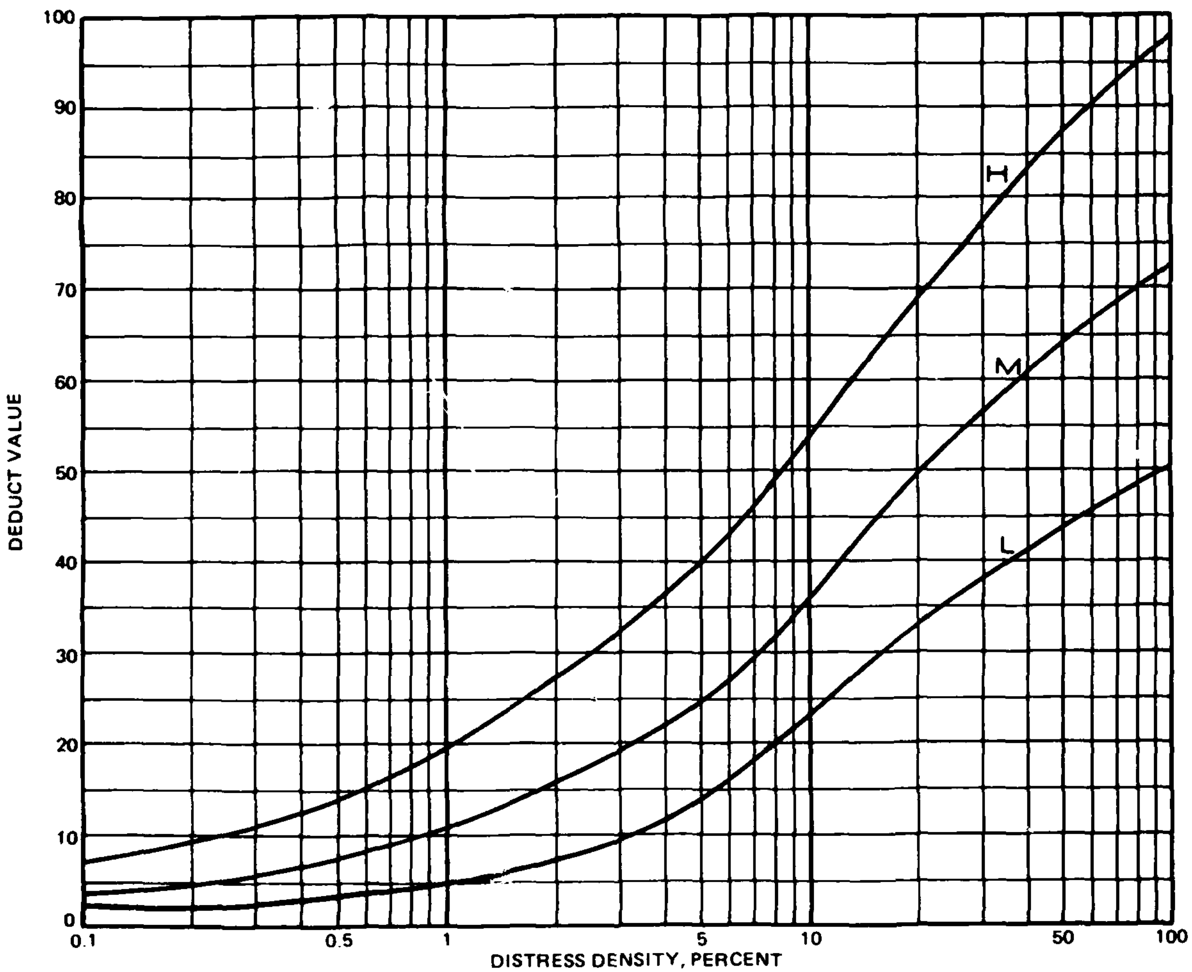


Figure A-36. Flexible pavement deduct values, distress 8, longitudinal and transverse cracking

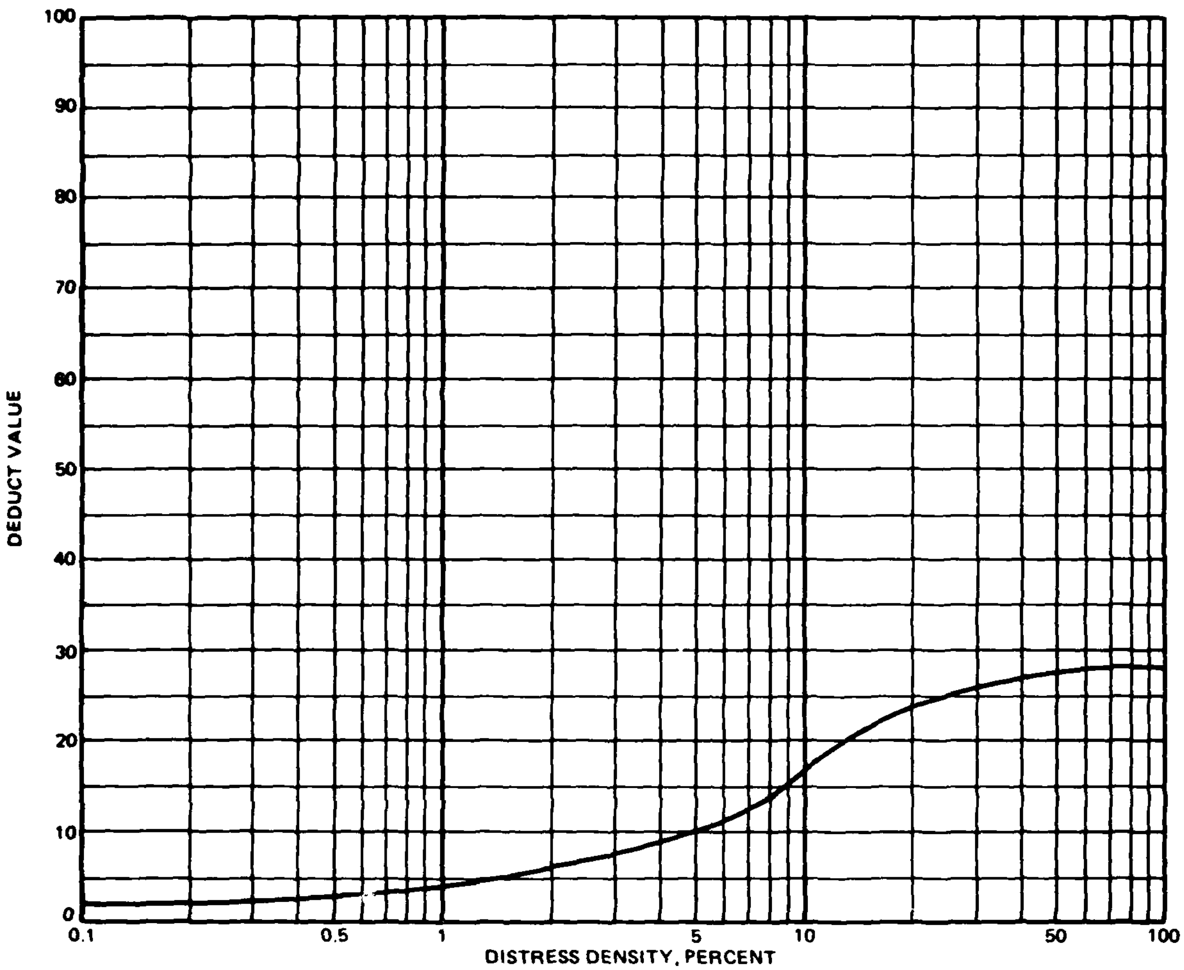


Figure A-37. Flexible pavement deduct values, distress 9, oil spillage

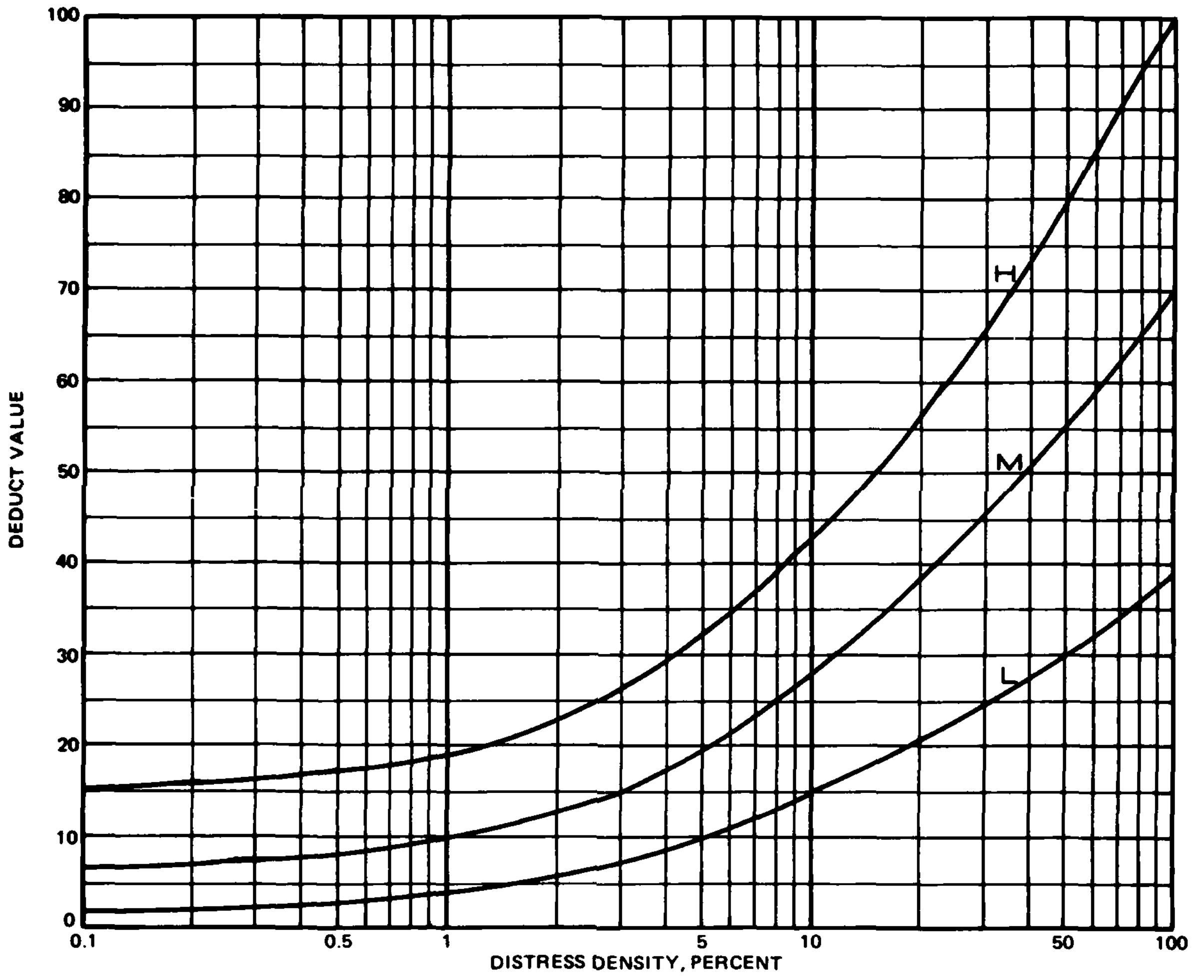


Figure A-38. Flexible pavement deduct values, distress 10, patching and utility cut

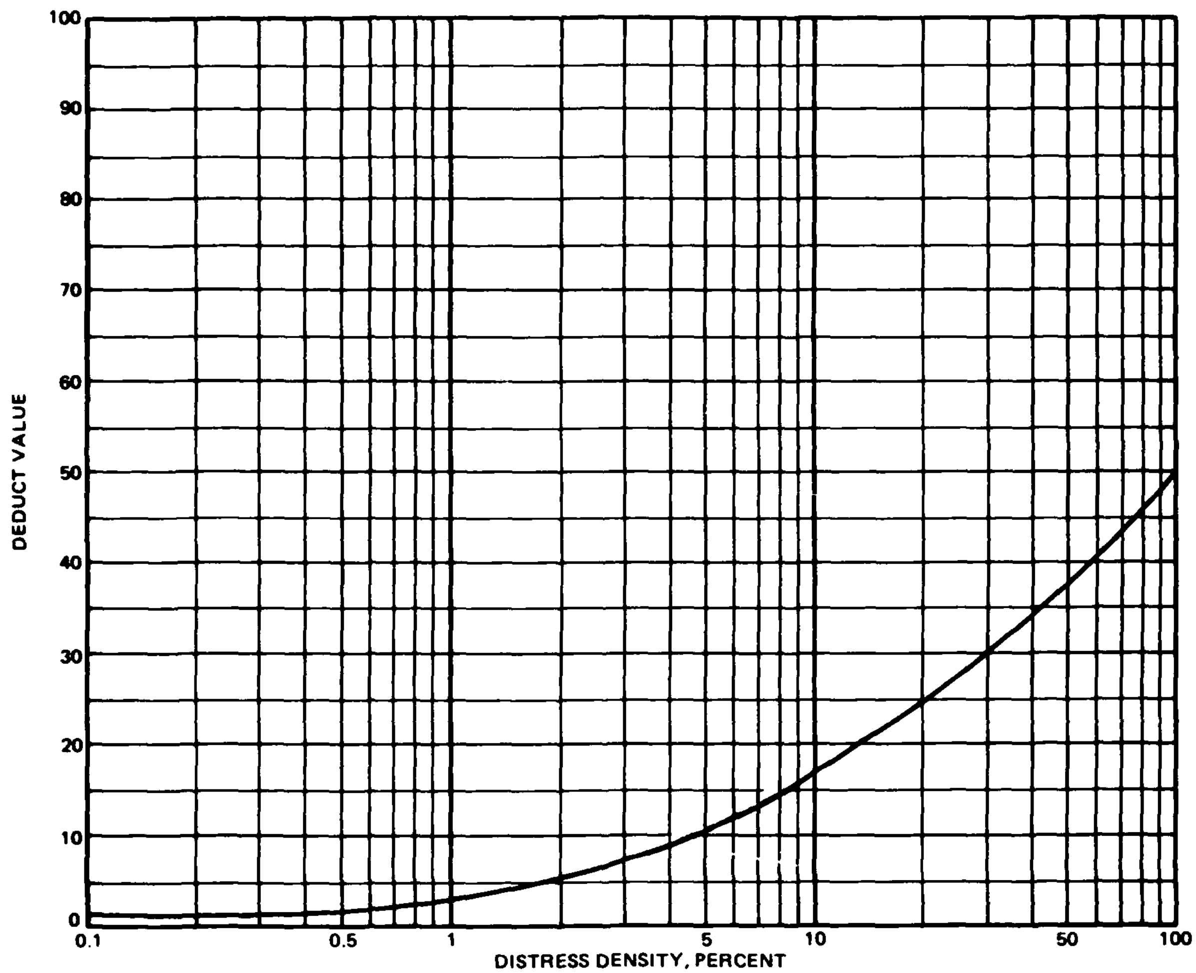


Figure A-39. Flexible pavement deduct values, distress 11, polished aggregate

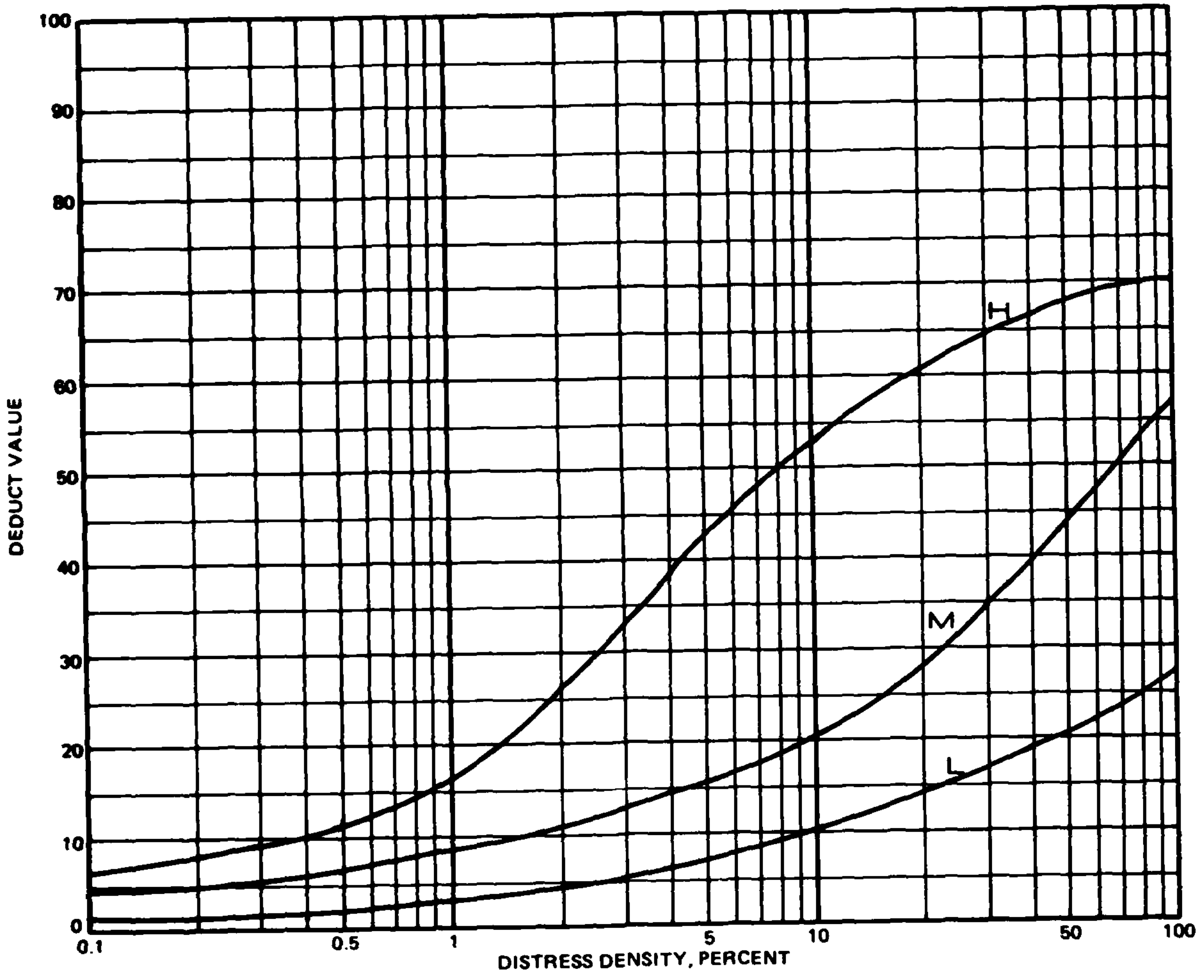


Figure A-40. Flexible pavement deduct values, distress 12, raveling/weathering

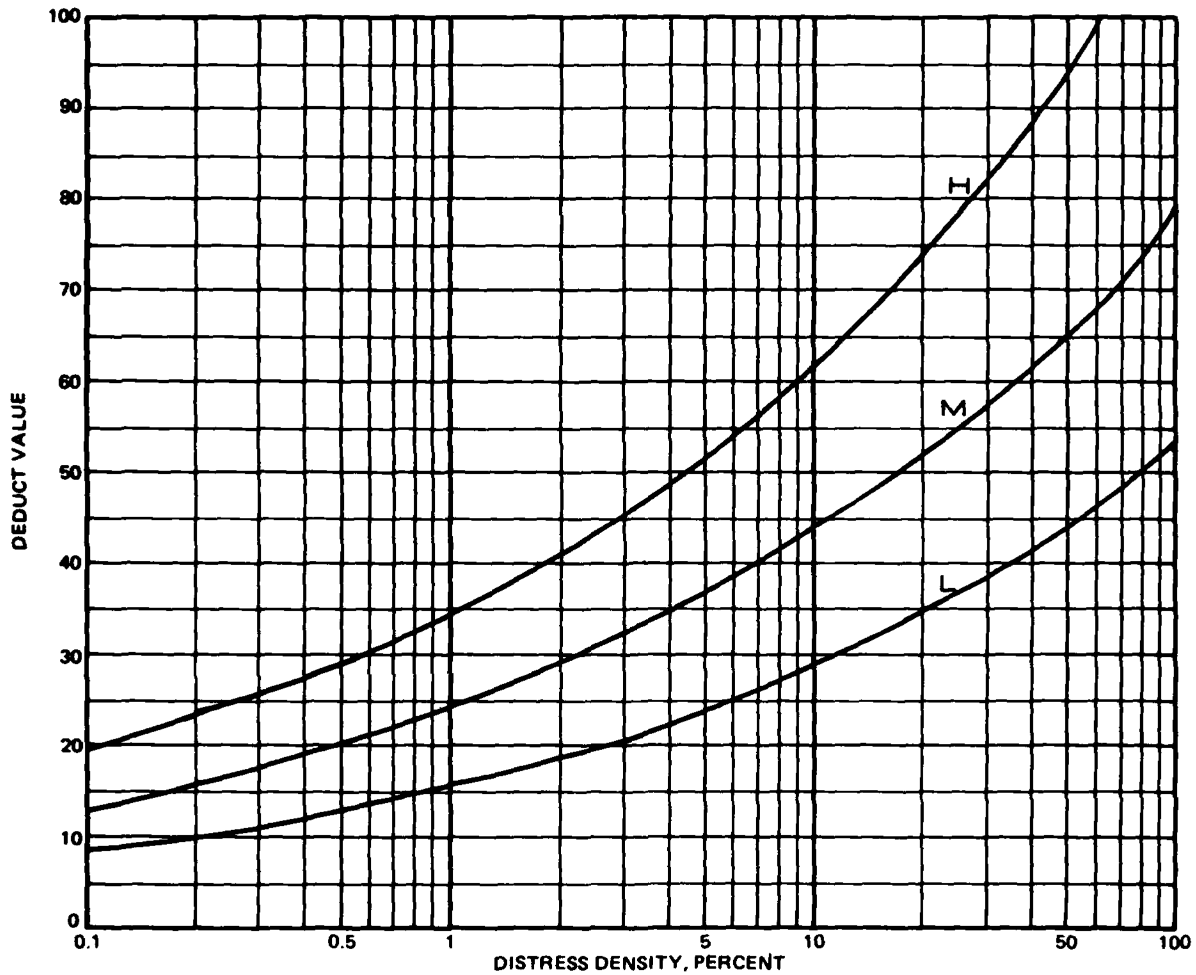


Figure A-41. Flexible pavement deduct values, distress 13, rutting

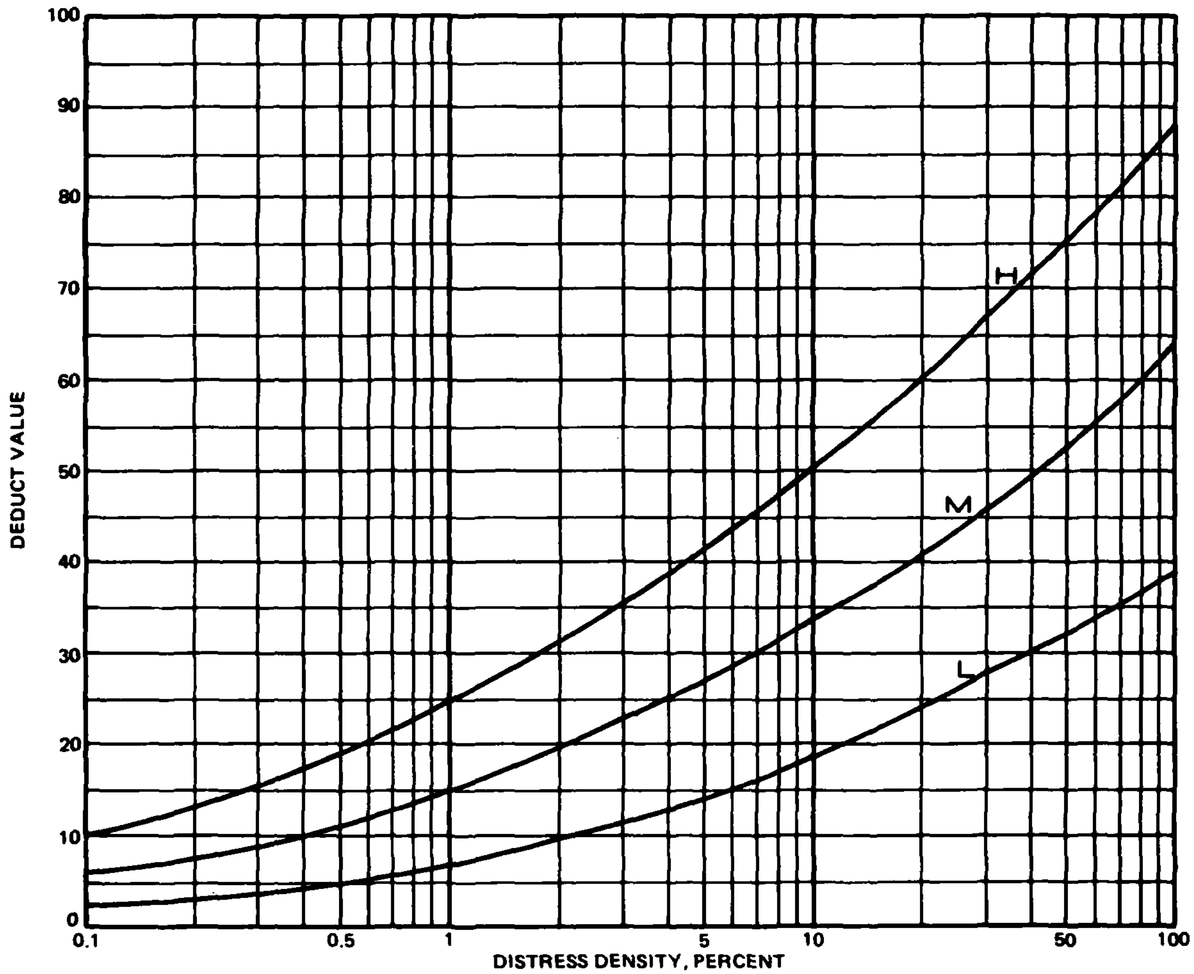


Figure A-42. Flexible pavement deduct values, distress 14, shoving of flexible pavement by PCC slabs

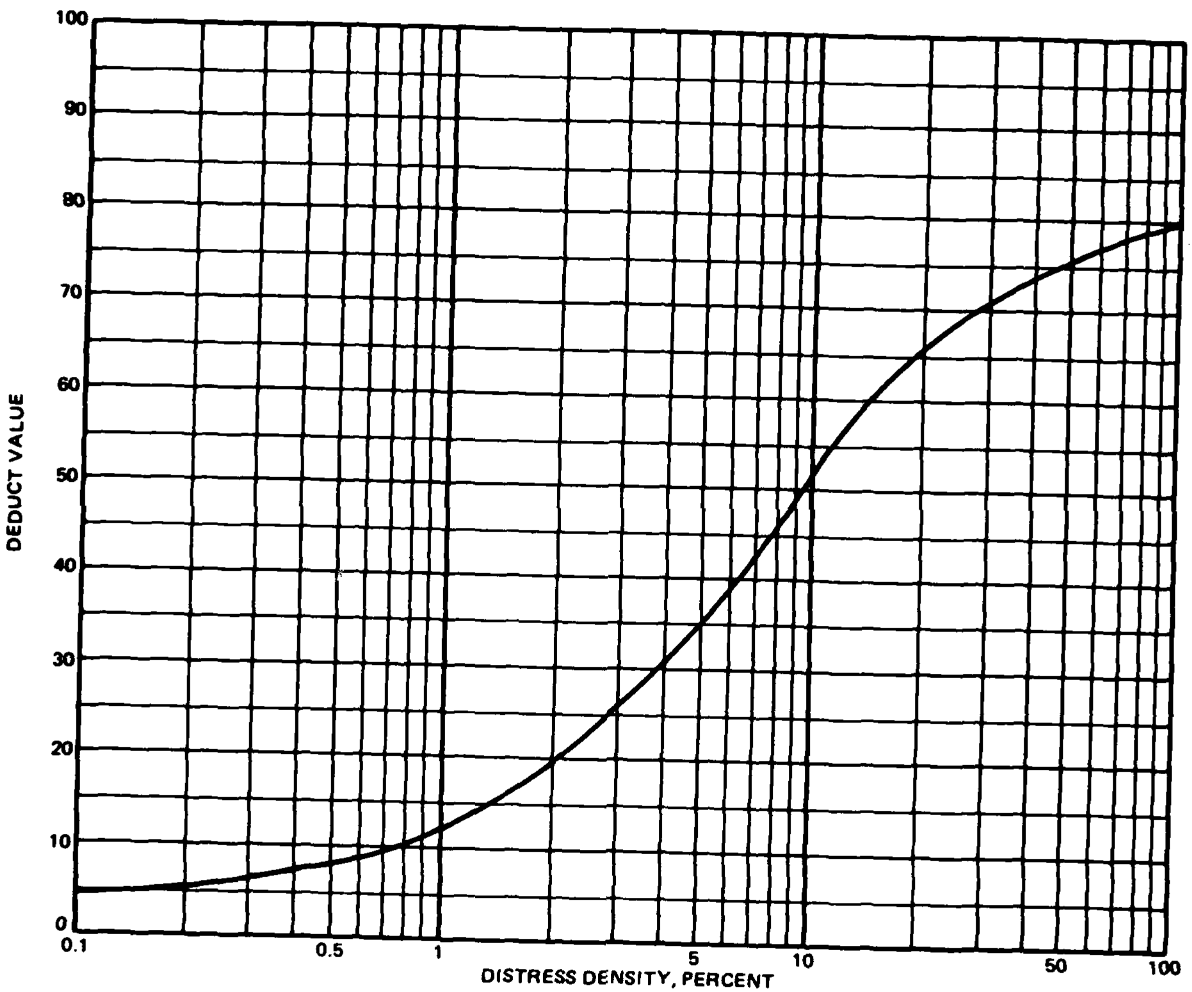


Figure A-43. Flexible pavement deduct values, distress 15, slippage cracking

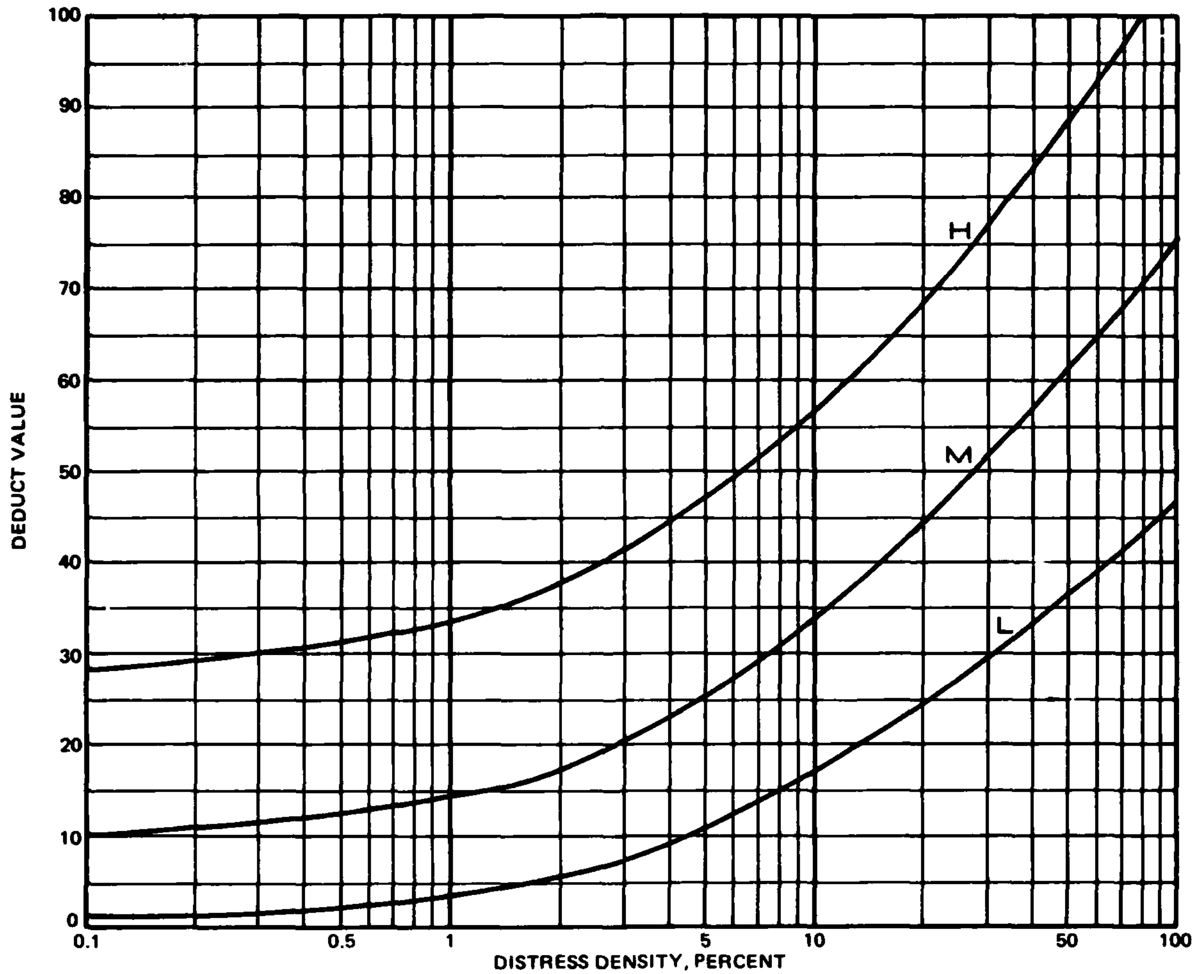


Figure A-44. Flexible pavement deduct values, distress 16, swell

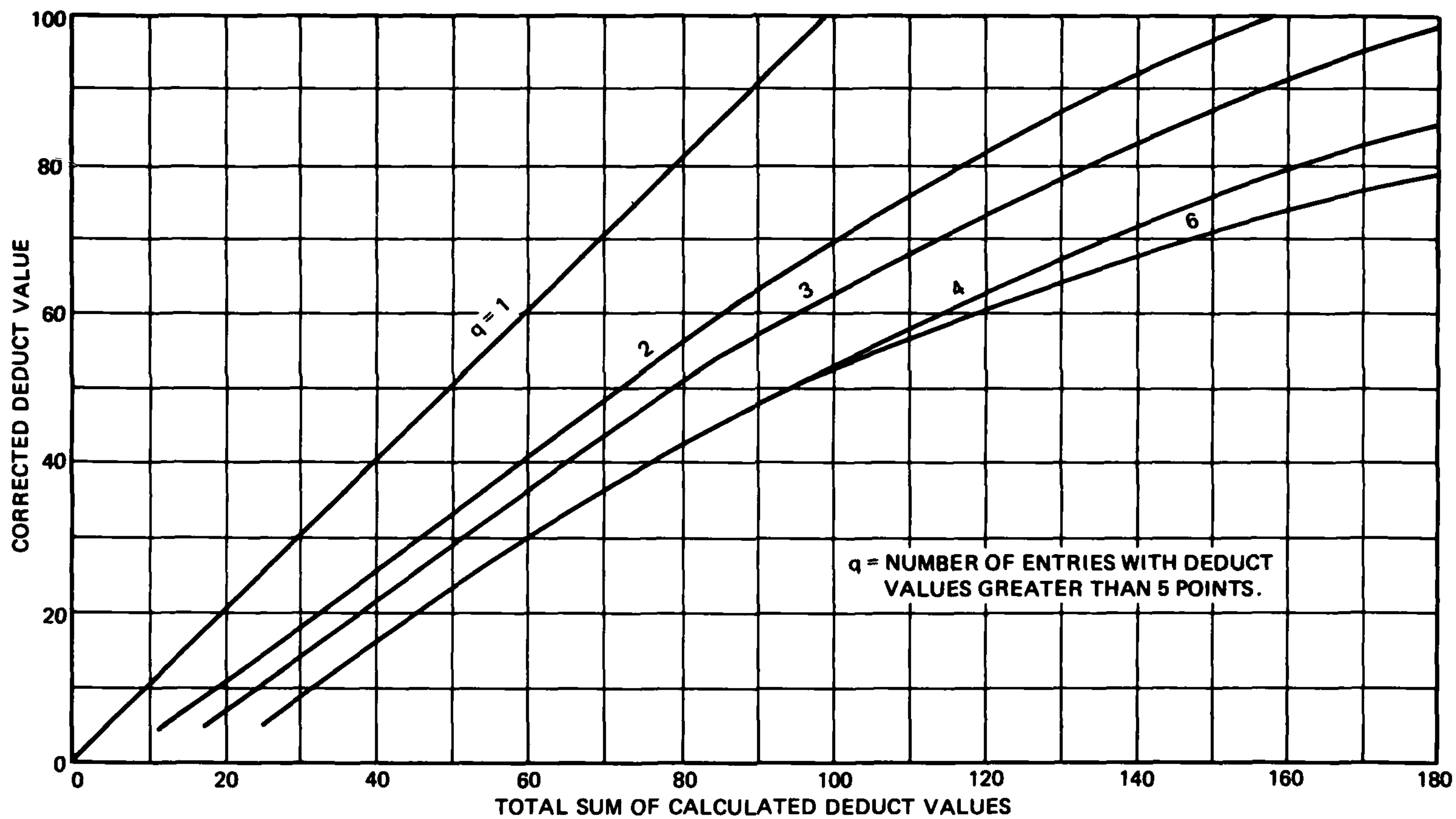


Figure A-45. Corrected deduct values for flexible pavements

Airport: World International

Airport Facility: Taxiway 5

Total No. of Sample Units: 25

Date of Survey: 26 March 1979

Sample Unit No.	Sample Unit Area, ft^2	PCI
1	5000	42
2	5000	33
3	5000	53
4	5000	39
5	5000	23
6	5000	25
7	5000	36
8	5000	38
9	5000	35
10	5000	25
11	5000	32
12	5000	45
13	5000	40
14	5000	55
15	5000	46
16	5000	35
17	5000	22
18	5000	30
19	5000	39
20	5000	35
21	5000	32
22	5000	41
23	5000	49
24	5000	30
25	5000	22

Average PCI for Feature: 36

Condition Rating: Poor

Figure A-46. Feature summary for flexible pavements

APPENDIX B: AIRPORT PAVEMENT DISTRESS IDENTIFICATION MANUAL

OBJECTIVE

The objective of this manual is to provide pavement inspectors with a standardized reference for airport pavement distress identification. The distress information is to be used in conjunction with the procedures presented in the main text of this report to determine pavement condition and maintenance and repair requirements.

USE OF THE MANUAL

The types of airport pavement distress are listed alphabetically under the major categories of flexible pavements and jointed rigid pavements. Names, descriptions, severity levels, photographs, and measurement or count criteria presented for each distress were established based on the effect of the pavement's structural integrity, operational condition, and maintenance and repair requirements.

It is very important that the pavement inspector be able to identify all distress types and their severity levels. The inspector should study this manual prior to performing an inspection and should carry a copy for reference during the inspection.

It should be emphasized that pavement inspectors must follow the distress descriptions in this manual in order to arrive at meaningful and consistent PCI values.

Several items that are commonly encountered are outlined in Table B-1 for emphasis, and the rater should be aware of these frequently occurring items before starting the condition survey.

DISTRESSES IN FLEXIBLE PAVEMENTS

ALLIGATOR OR FATIGUE CRACKING - DISTRESS NO. 1

Description.

a. Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphaltic concrete (AC) surface under repeated traffic loading. The cracking initiates at the bottom of the AC surface (or stabilized

Table B-1

Frequently Occurring Identification Problems in Pavement Distress Identification

Situation	Action	Remarks
Distress in Flexible Pavements		
1. Alligator cracking and rutting in same area.	Record each separately at respective severity level.	
2. Bleeding has been counted in area.	Polished aggregate is not counted in same area.	
3. Polished aggregate in very small amount.	Do not count.	Polished aggregate is only counted when there is a significant amount.
4. Any distress (including cracking) in a patched area.	Do not record.	Effect of distress is considered in patch severity level.
5. For asphalt pavements if block cracking is recorded.	No longitudinal and transverse cracking should be recorded.	Does not apply to asphaltic concrete (AC) over portland cement concrete (PCC).
6. For asphalt overlay over concrete.	Block cracking, jointed reflection cracking, and longitudinal and transverse cracking reflected from old concrete is recorded separately.	AC over PCC could have, for example, 100 percent block cracking, 10 percent joint reflection cracking, and 1 percent longitudinal and transverse cracking.
Distress in Jointed Rigid Pavements		
1. Low-severity scaling (i.e., crazing).	Count only if it is probable future scaling will occur within 2 to 3 years.	
2. Joint seal damage.	This is not counted on a slab-by-slab basis.	A severity level based on the overall condition of the joint seal in the sample unit is assigned.

(Continued)

Table B-1 (Concluded)

Situation	Action	Remarks
Distress in Jointed Rigid Pavements (Continued)		
3. Joint spall small enough to be filled during a joint seal repair.	Do not record.	
4. For a medium- or high-severity slab.	No other distress should be counted.	
5. Corner or joint spalling caused by "D" cracking.	Only "D" cracking should be recorded.	If spalls are caused by factors other than "D" cracking, record each factor separately.
6. Crack repaired by a narrow patch (e.g., 4 to 10 in. wide).	Record only crack and not patch at appropriate severity level.	
7. Original distress of patch is more severe than patch itself.	Original distress type should be recorded.	If, for example, patch material is present on scaled area of slab, only the scaling is counted.

AD-A089 437 ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 1/5
PROCEDURE FOR CONDITION SURVEY OF CIVIL AIRPORTS.(U)
MAY 80 J W HALL, D R ELSEA DOT-FA78WAI-846

UNCLASSIFIED FAA-RD-80-55 NL

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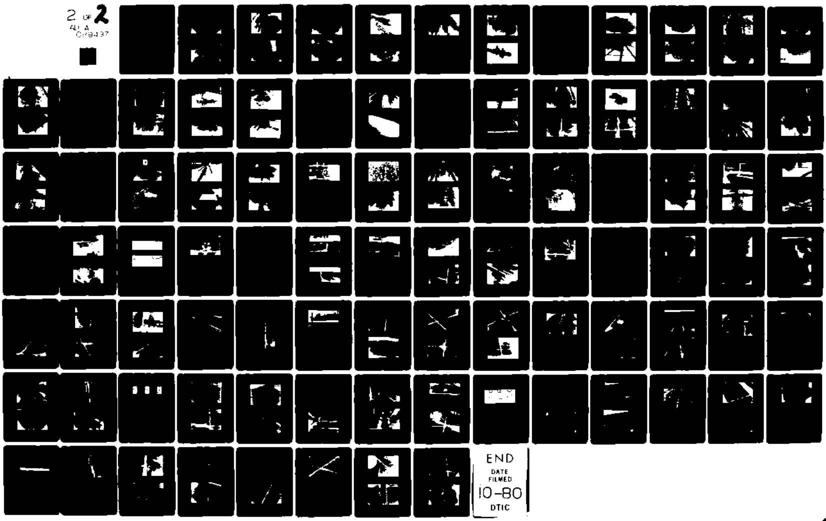

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base) where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel cracks. After repeated traffic loading, the cracks connect, forming many-sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are less than 2 ft on the longest side.

b. Alligator cracking occurs only in areas that are subjected to repeated traffic loadings, such as wheel paths. Therefore, it would not occur over an entire area unless the entire area was subjected to traffic loading. Pattern-type cracking, which occurs over an entire area that is not subjected to loading, is rated as block cracking, which is not a load-associated distress.

c. Alligator cracking is considered a major structural distress.

Severity Levels.

a. Low severity level (L). Fine, longitudinal hairline cracks running parallel to one another with none or only a few interconnecting cracks. The cracks are not spalled (Figures B-1 through B-3).

b. Medium severity level (M). Further development of light alligator cracking into a pattern or network of cracks that may be lightly spalled (Figures B-4 through B-8).

c. High severity level (H). Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges; some of the pieces rock under traffic (Figure B-9).

Measuring Procedure. Alligator cracking is measured in square feet of surface area. The major difficulty in measuring this type of distress is that many times two or three levels of severity exist within one distressed area. If these portions can be easily distinguished from one another, they should be measured and recorded separately. However, if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present.

BLEEDING - DISTRESS NO. 2

Description. Bleeding is a film of bituminous material on the pavement surface that creates a shiny, glasslike, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphaltic cement or tars in the mix and/or low air void content. It occurs when asphalt fills the voids of the mix during hot

Figure B-1. Low severity alligator cracking, case 1

Figure B-2. Low severity alligator cracking, case 2

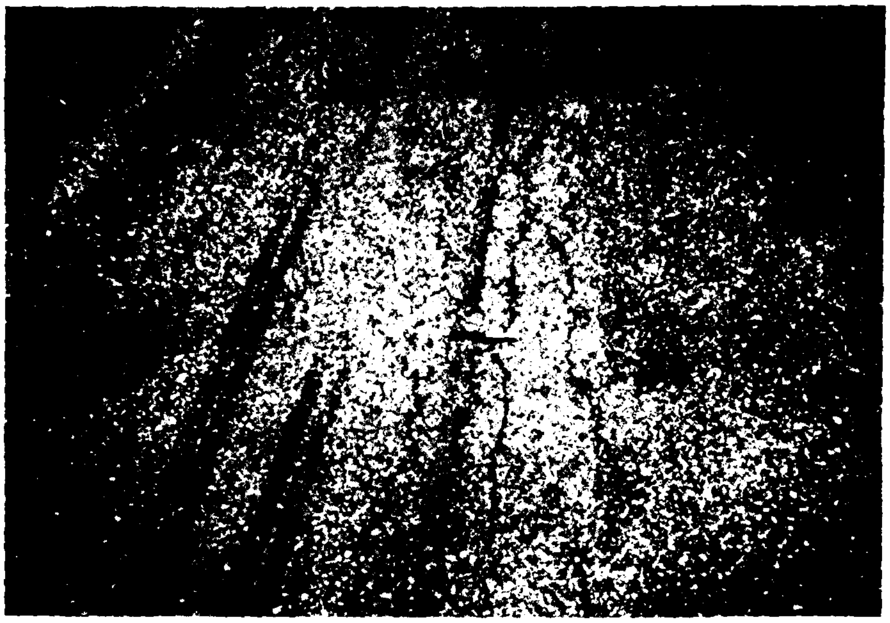

Figure B-3. Low severity alligator cracking, approaching medium severity

Figure B-4. Medium severity alligator cracking, case 1 (Note the depression occurring with the cracking.)

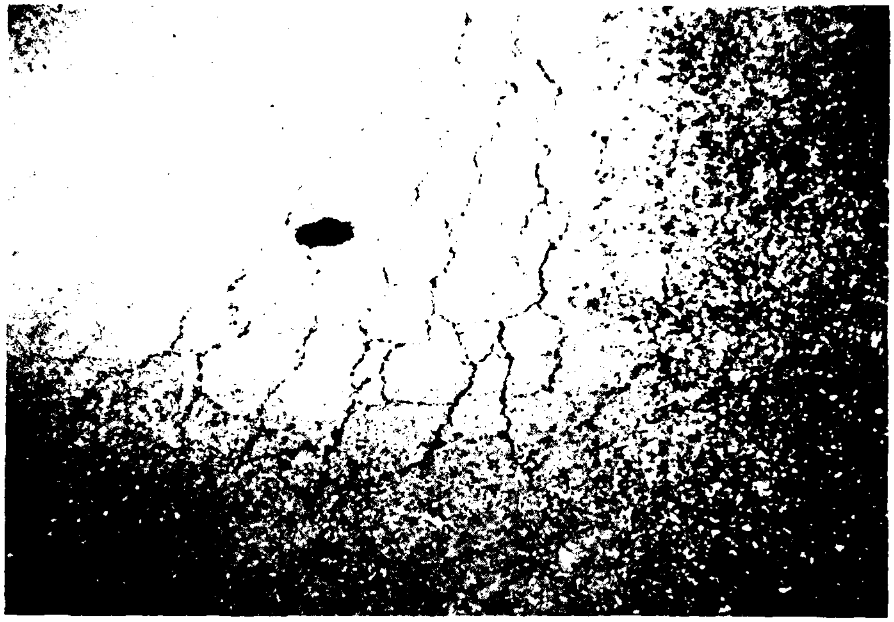

Figure B-5. Medium severity alligator cracking, case 2

Figure B-6. Medium severity alligator cracking, case 3

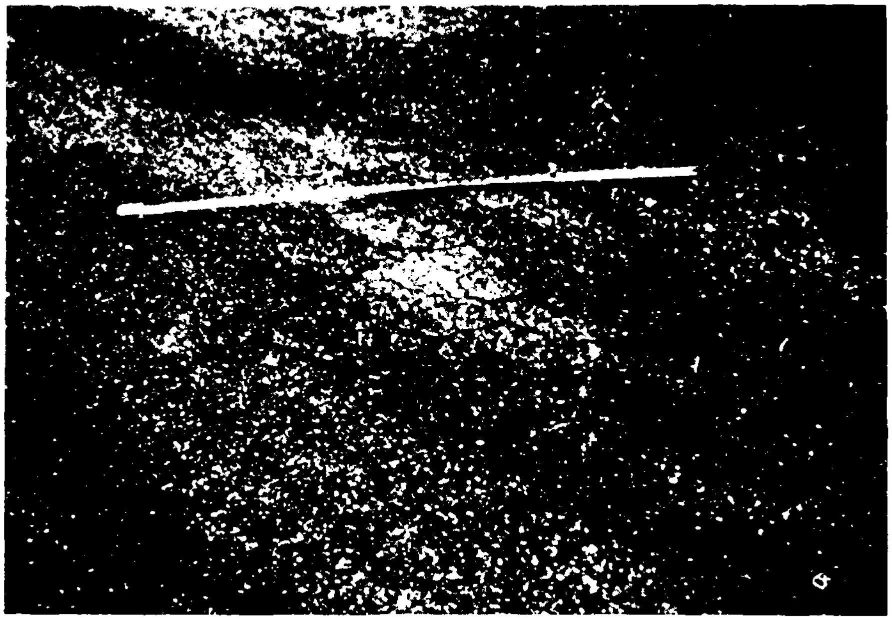

Figure B-7. Medium severity alligator cracking, approaching high severity, case 1

Figure B-8. Medium severity alligator cracking, approaching high severity, case 2

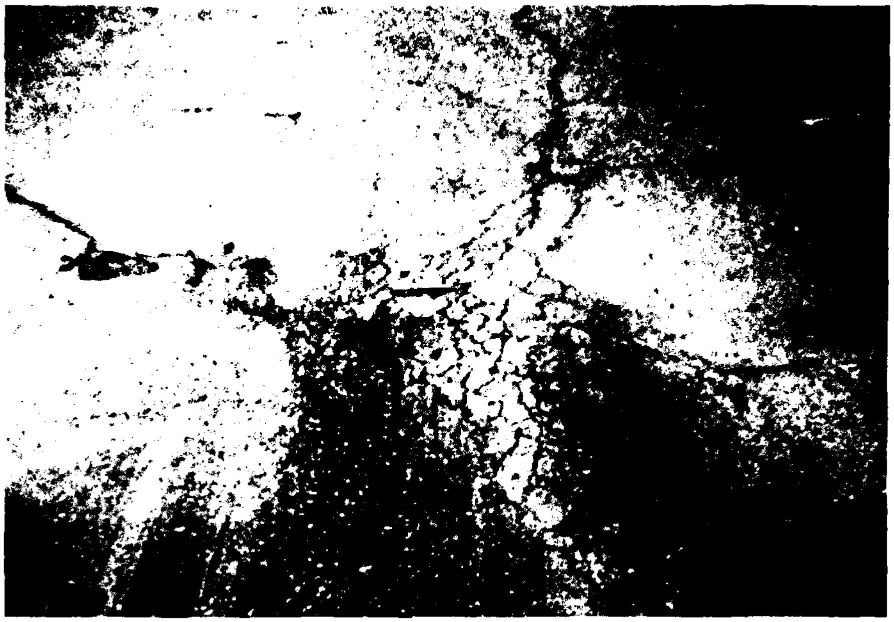

Figure B-9. High severity alligator cracking

weather and then expands out onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface.

Severity Levels. No degrees of severity are defined. Bleeding should be noted when it is extensive enough to cause a reduction in skid resistance (Figures B-10 and B-11).

Measuring Procedure. Bleeding is measured in square feet of surface area.

BLOCK CRACKING - DISTRESS NO. 3

Description. Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 by 1 ft to 10 by 10 ft. When the blocks are larger than 10 by 10 ft, they are classified as longitudinal or transverse cracking. Block cracking is caused mainly by shrinkage of the asphaltic concrete and daily temperature cycling (which results in daily stress/strain cycling). It is not load-associated. The occurrence of block cracking usually indicates that the asphalt has hardened

Figure B-10. Bleeding

Figure B-11. Close-up of Figure B-10

significantly. Block cracking normally occurs over a large portion of pavement area, but sometimes will occur only in nontraffic areas. This type of distress differs from alligator cracking in that the alligator cracks form smaller, many-sided pieces with sharp angles. Also unlike block cracks, alligator cracks are caused by repeated traffic loadings and are, therefore, located only in traffic areas (i.e., wheel paths).

Severity Levels.

a. Low severity level (L). Blocks are defined by cracks that are nonspalled (sides of the crack are vertical) or only lightly spalled with no loose particles. Nonfilled cracks have 1/4 in. or less mean width, and filled cracks have a filler in satisfactory condition (Figures B-12 through B-15).

b. Medium severity level (M).

(1) Filled or nonfilled cracks that are moderately spalled with some loose particles.

(2) Nonfilled cracks that are not spalled or have only minor spalling with few loose particles but have a mean width greater than approximately 1/4 in.

(3) Filled cracks that are not spalled or have only minor spalling with a few loose particles, but have filler in unsatisfactory condition (Figures B-16 and B-17).

c. High severity level (H). Blocks are well defined by cracks that are severely spalled with loose and missing particles (Figures B-18 through B-20).

Measuring Procedure. Block cracking is measured in square feet of surface area, and usually occurs at one severity level in a given pavement section. Any areas of the pavement section having distinctly different levels of severity, however, should be measured and recorded separately.

CORRUGATION - DISTRESS NO. 4

Description. Corrugation is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals (usually less than 5 ft) along the pavement. The ridges are perpendicular to the traffic direction. Traffic action combined with an unstable pavement surface or base usually causes this type of distress.

Severity Levels.

a. Low severity level (L). Corrugations are minor and do not significantly affect ride quality (see measurement criteria below) (Figure B-21).

Figure B-12. Low severity block cracking

Figure B-13. Low severity block cracking, filled cracks, case 1

Figure B-14. Low severity block cracking, filled cracks, case 2

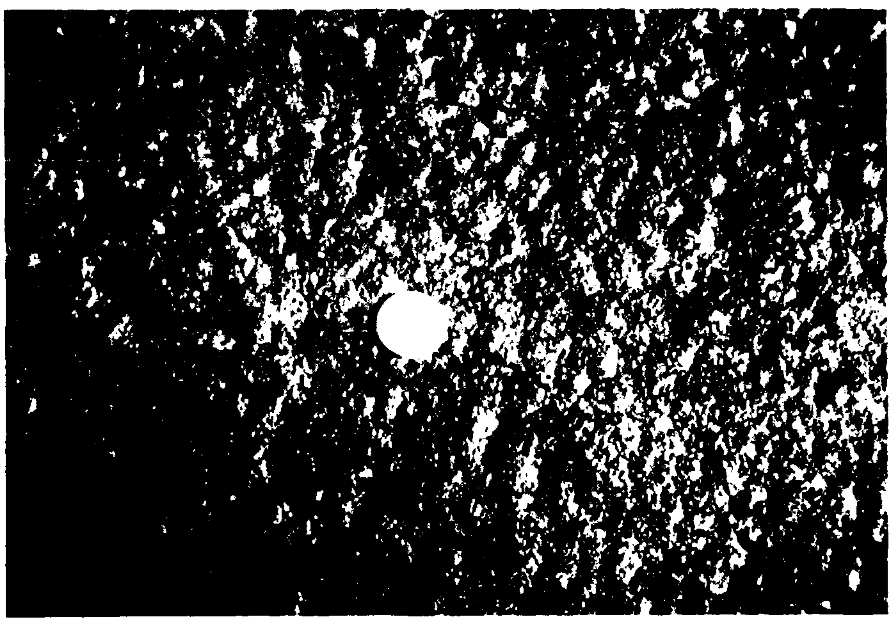

Figure B-15. Low severity block cracking, small blocks defined by hairline cracks

Figure B-16. Medium severity block cracking, case 1

Figure B-17. Medium severity block cracking, case 2

Figure B-18. High severity block cracking, case 1

Figure B-19. High severity block cracking, case 2

Figure B-20. High severity block cracking, case 3

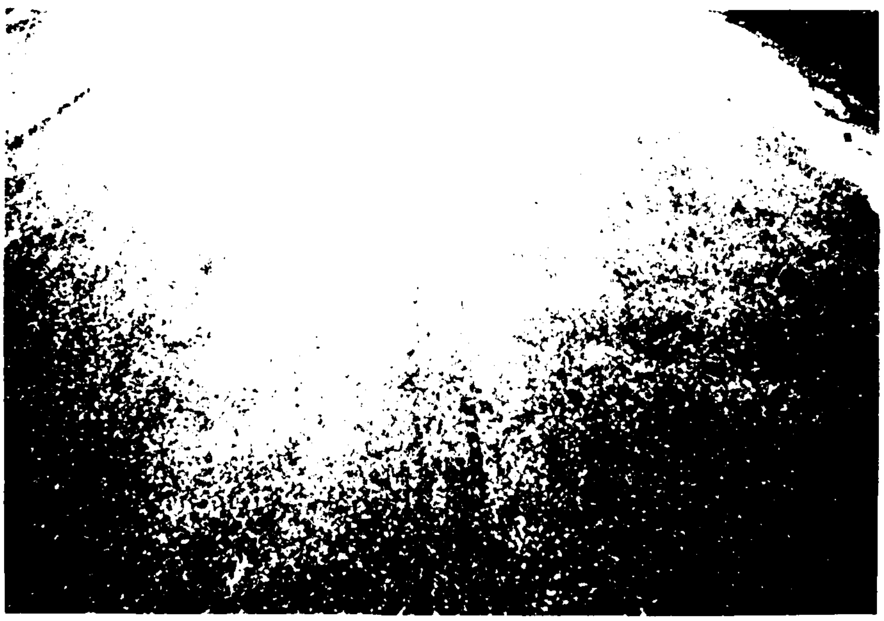

Figure B-21. Low severity corrugation in the foreground, changing to medium and high in the background

b. Medium severity level (M). Corrugations are noticeable and significantly affect ride quality (see measurement criteria below) (Figure B-22).

c. High severity level (H). Corrugations are easily noticed and severely affect ride quality (see measurement criteria below) (Figure B-23).

Measuring Procedure. Corrugation is measured in square feet of surface area. The mean elevation difference between the ridges and valleys of the corrugations indicates the level of severity. To determine the mean elevation difference, a 10-ft straightedge should be placed perpendicular to the corrugations so that the depth of the valleys can be measured in inches. The mean depth is calculated from five such measurements.

Severity	Runways and High-Speed Taxiways	Taxiways and Aprons
L	$<1/4$ in.	$<1/2$ in.
M	1/2-1/2 in.	1/2-1 in.
H	$\geq 1/2$ in.	≥ 1 in.

Some of the following photographs were taken on roads and streets. Corrugation is not commonly found on airport pavements.

DEPRESSION - DISTRESS NO. 5

Description. Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates "birdbath" areas; but the depressions can also be located without rain because of stains created by ponding of water. Depressions can be caused by settlement of the foundation soil or can be built during construction. Depressions cause roughness and, when filled with water of a sufficient depth, could cause hydroplaning of aircraft.

Severity Levels.

a. Low severity level (L). Depression can be observed or located by stained areas, only slightly affects pavement riding quality, and may cause hydroplaning potential on runways (see measurement criteria below) (Figure B-24).

Figure B-22. Medium severity corrugation

Figure B-23. High severity corrugation

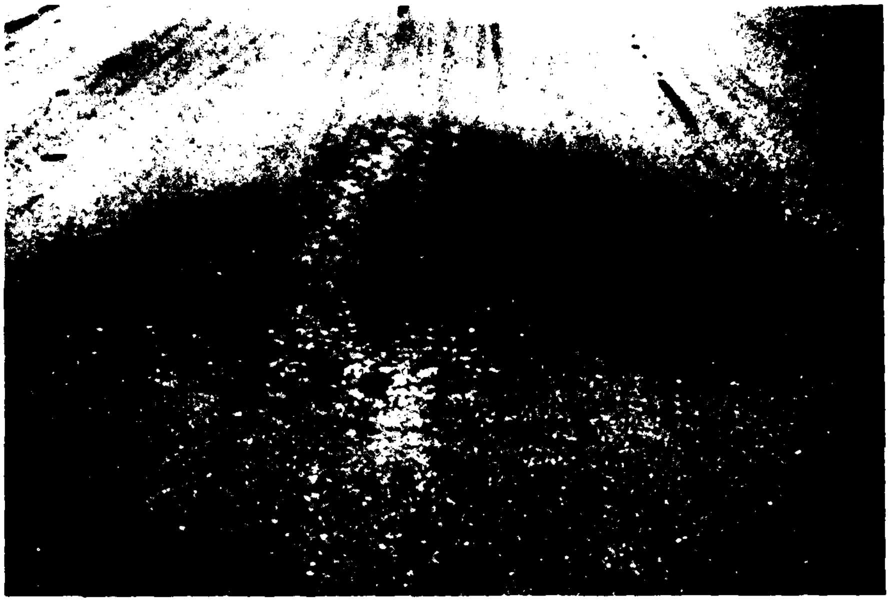

Figure B-24. Low severity depression

b. Medium severity level (M). The depression can be observed, moderately affects pavement riding quality, and causes hydroplaning potential on runways (see measurement criteria below) (Figures B-25 and B-26).

Figure B-25. Medium severity depression (>1/2 in.), case 1

Figure B-26. Medium severity depression (> 1/2 in.), case 2

c. High severity level (H). The depression can be readily observed, severely affects pavement riding quality, and causes definite hydroplaning potential (see measurement criteria below) (Figure B-27).

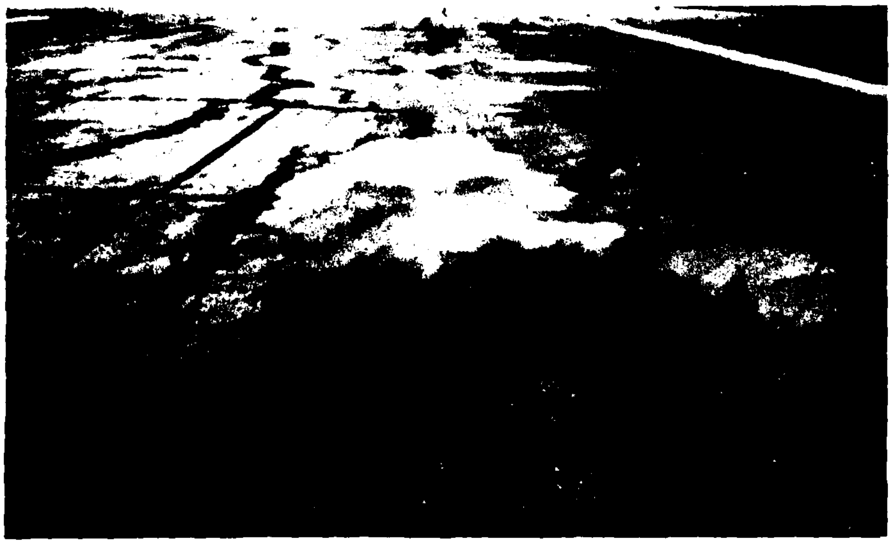

Figure B-27. High severity depression (2 in.)

Measuring Procedure. Depressions are measured in square feet of surface area. The maximum depth of the depression determines the level of severity. This depth can be measured by placing a 10-ft straightedge across the depressed area and measuring the maximum depth in inches. Depressions larger than 10 ft across must be measured by either visual estimation or by direct measurement when filled with water.

Maximum Depth of Depression

Severity	Runways and High-Speed Taxiways	Taxiways and Aprons
L	1/8-1/2 in.	1/2-1 in.
M	1/2-1 in.	1-2 in.
H	>1 in.	>2 in.

JET BLAST EROSION -
DISTRESS NO. 6

Description. Jet blast erosion causes darkened areas on the pavement surface where bituminous binder has been burned or carbonized. Localized burned areas may vary in depth up to approximately 1/2 in.

Severity Levels. No degrees of severity are defined. It is sufficient to indicate that jet blast erosion exists (Figures B-28 and B-29).

Measuring Procedure. Jet blast erosion is measured in square feet of surface area.

JOINT REFLECTION CRACKING
FROM PCC (LONGITUDINAL AND
TRANSVERSE) - DISTRESS NO. 7

Description. This distress occurs only on pavements having an asphalt or tar surface over a portland cement concrete (PCC) slab. This category does not include reflection cracking from any other type of base (i.e., cement stabilized, lime stabilized). Such cracks are listed as longitudinal and transverse cracks. Joint reflection cracking is caused mainly by movement of the PCC slab beneath the asphaltic concrete (AC) surface because of thermal and moisture changes. It is not load-related. However, traffic loading may cause a breakdown of the AC near

Figure B-28. Jet blast erosion, case 1

Figure B-29. Jet blast erosion, case 1

the crack, resulting in spalling. If the pavement is fragmented along a crack, the crack is said to be spalled. A knowledge of slab dimensions beneath the AC surface will help to identify these cracks.

Severity Levels.

a. Low severity level (L). Cracks have only little or no spalling and can be filled or nonfilled. If nonfilled, the cracks have a mean width of 1/4 in. or less. Filled cracks are of any width, but their filler material is in satisfactory condition (Figures B-30 through B-32).

b. Medium severity level (M). One of the following conditions exists:

(1) Cracks are moderately spalled with some loose particles and can be either filled or nonfilled and of any width.

(2) Filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition.

(3) Nonfilled cracks are not spalled or are only lightly spalled, but the mean crack width is greater than 1/4 in.

(4) Light random cracking exists near the crack or at the corners of intersecting cracks (Figures B-33 through B-35).

c. High severity level (H). Cracks are severely spalled with loose and missing particles and can be either filled or nonfilled and of any width (Figure B-36).

Measuring Procedure. Joint reflection cracking is measured in linear feet. The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion should be recorded separately. For example, a crack that is 50 ft long may have 10 ft of a high severity crack, 20 ft of a medium severity, and 20 ft of a light severity. These would all be recorded separately.

LONGITUDINAL AND TRANSVERSE CRACKING (NON-PCC JOINT REFLECTIVE) - DISTRESS NO. 8

Description. Longitudinal cracks are parallel to the pavement's center line or laydown direction. They may be caused by (a) a poorly constructed paving lane joint, (b) shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or (c) a reflective crack caused by cracks beneath the surface course, including cracks in PCC

Figure B-30. Low severity joint reflection cracking

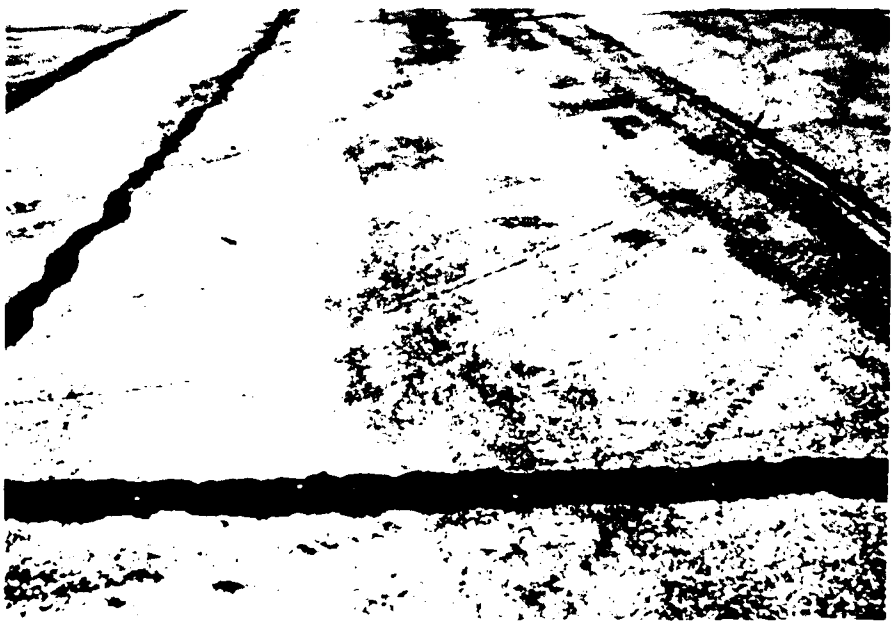

Figure B-31. Low severity joint reflection cracking, filled crack

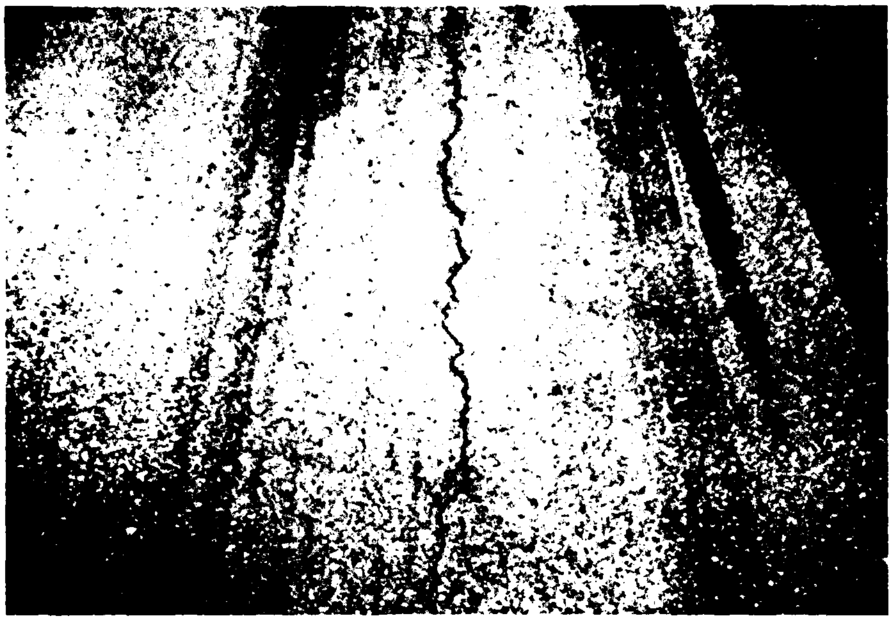

Figure B-32. Low severity joint reflection cracking, nonfilled crack

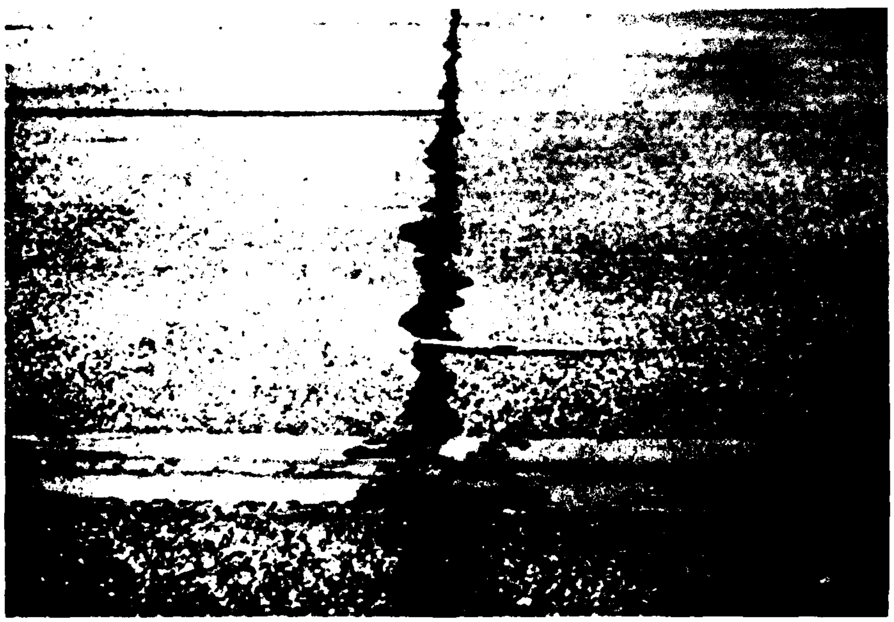

Figure B-33. Medium severity joint reflection cracking, case 1

Figure B-34. Medium severity joint reflection cracking, case 2

Figure B-35. Medium severity joint reflection cracking, case 3

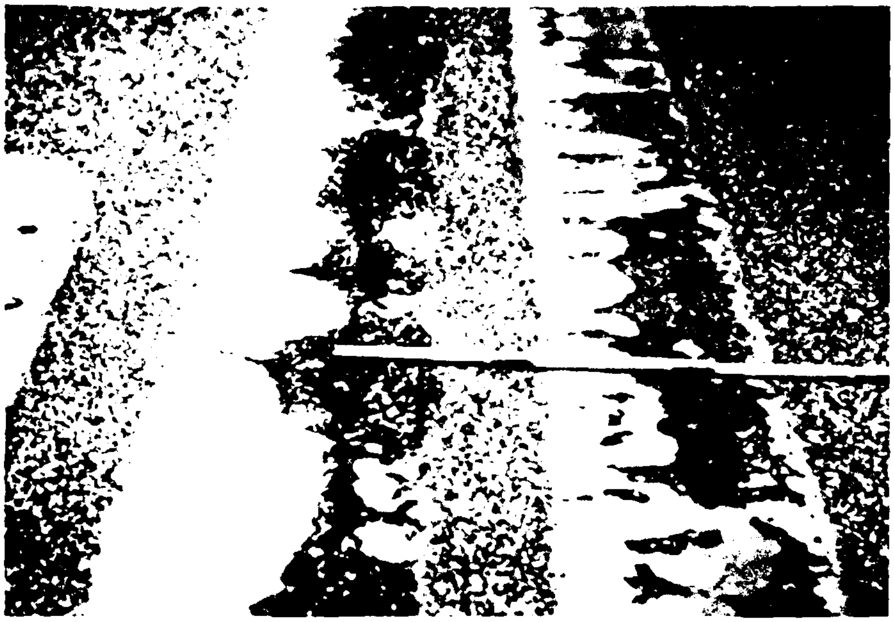

Figure B-36. High severity joint reflection cracking

slabs (but not at PCC joints). Transverse cracks extend across the pavement at approximately right angles to the pavement's center line or direction of laydown. They may be caused by items b or c above. These types of cracks are not usually load-associated. If the pavement is fragmented along cracks, the crack is said to be spalled.

Severity Levels.

a. Low severity level (L). Cracks have either little or no spalling with no loose particles. The cracks can be filled or nonfilled. Nonfilled cracks have a mean width of 1/4 in. or less. Filled cracks are of any width, but their filler material is in satisfactory condition (Figures B-37 and B-38).

b. Medium severity level (M). One of the following conditions exists:

(1) Cracks are moderately spalled with few loose particles and can be either filled or nonfilled of any width.

(2) Filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition.

(3) Nonfilled cracks are not spalled or are only lightly spalled, but mean crack width is greater than 1/4 in.

(4) Light random cracking exists near the crack or at the corners of intersecting cracks (Figures B-39 through B-41).

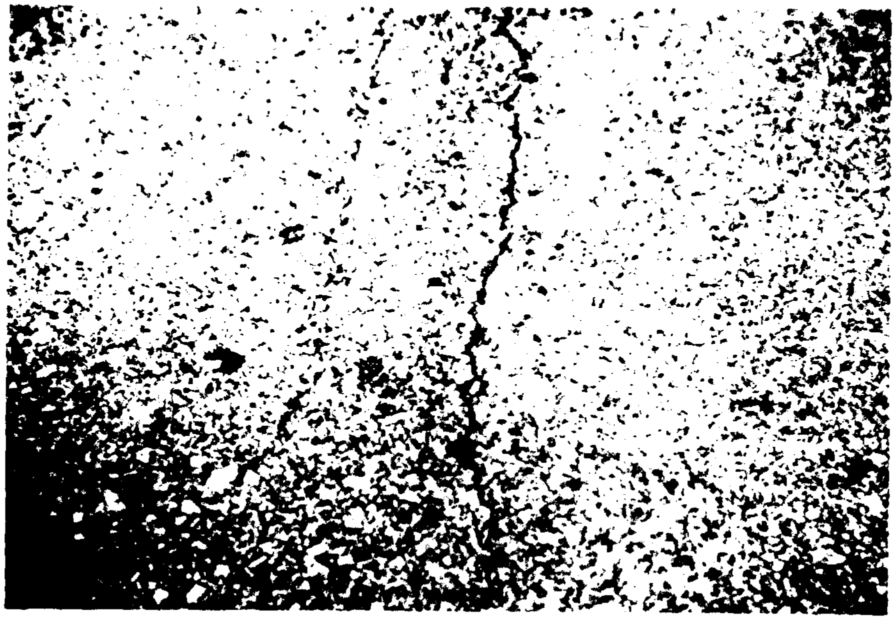

Figure B-37. Low severity longitudinal crack, flexible pavement

Figure B-38. Low severity longitudinal cracks, approaching medium, flexible pavement

Figure B-39. Medium severity longitudinal construction joint crack, flexible pavement, case 1

Figure B-40. Medium severity longitudinal crack, flexible pavement, case 2 (Note the crack is reflective but not at the joint of slab.)

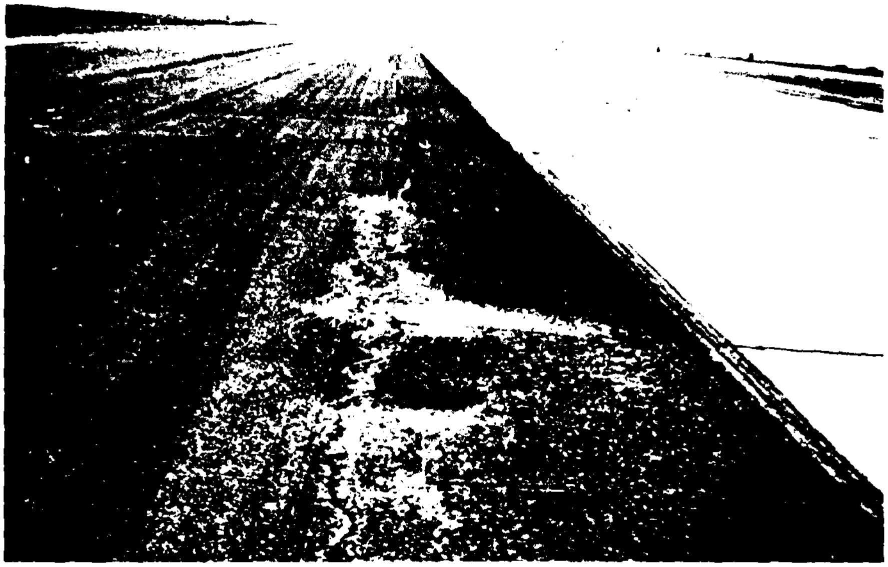

Figure B-41. Medium severity longitudinal crack, flexible pavement, case 3

c. High severity level (H). Cracks are severely spalled with loose and missing particles. They can be either filled or non-filled of any width (Figure B-42).

Figure B-42. High severity longitudinal crack, flexible pavement

Measuring Procedure. Longitudinal and transverse cracks are measured in linear feet. The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. For an example see joint reflection cracking.

OIL SPILLAGE - DISTRESS NO. 9

Description. Oil spillage is the deterioration or softening of the pavement surface caused by the spilling of oil, fuel, or other solvents (Figures B-43 and B-44).

Severity Levels. No degrees of severity are defined. It is sufficient to indicate that oil spillage exists.

Measuring Procedure. Oil spillage is measured in square feet of surface area.

PATCHING AND UTILITY CUT
PATCH - DISTRESS NO. 10

Description. A patch is considered a defect, no matter how well it is performing.

Severity Levels.

a. Low severity level (L). Patch is in good condition and is performing satisfactorily (Figures B-45 through B-47).

b. Medium severity level (M). Patch is somewhat deteriorated and affects riding quality to some extent (Figure B-48).

c. High severity level (H). Patch is badly deteriorated and affects ride quality significantly. Patch soon needs replacement (Figure B-49).

Measuring Procedure. Patching is measured in square feet of surface area. However, if a single patch has areas of differing severity levels, these areas should be measured and recorded separately. For example, a 25-sq-ft patch may have 10 sq ft of medium severity and 15 sq ft of light severity. These areas would be recorded separately.

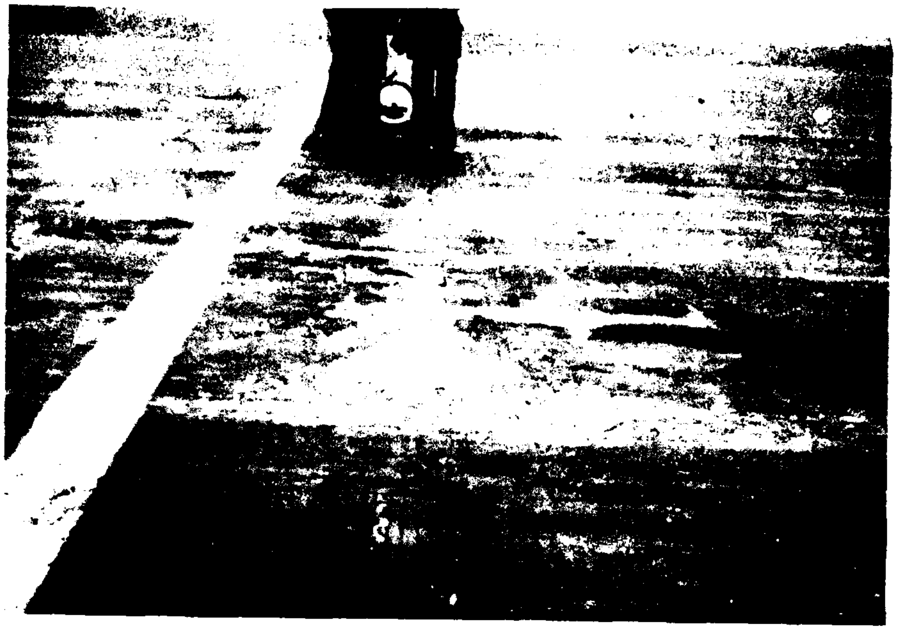

Figure B-43. Oil spillage, case 1

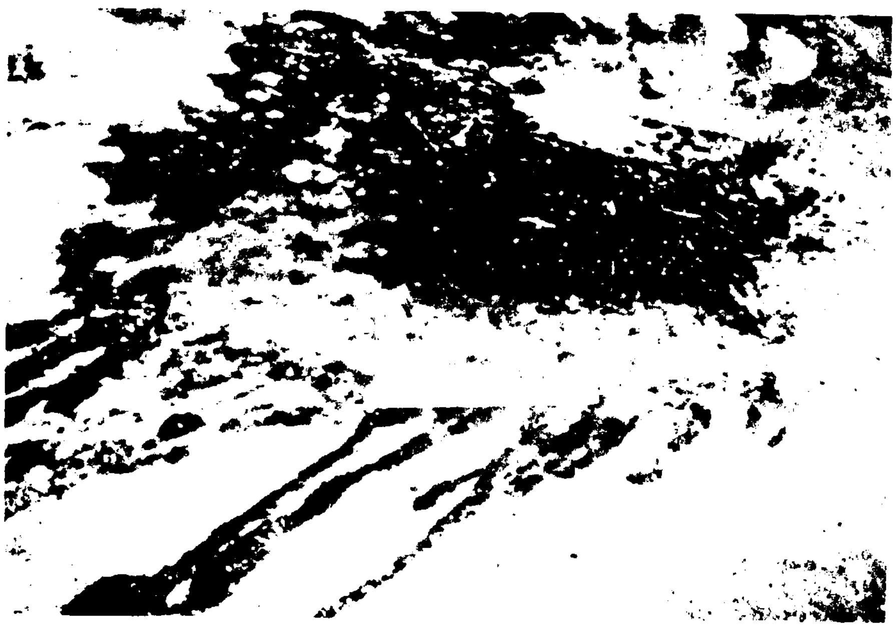

Figure B-44. Oil spillage, case 2

Figure B-45. Light severity patch, flexible pavement, case 1

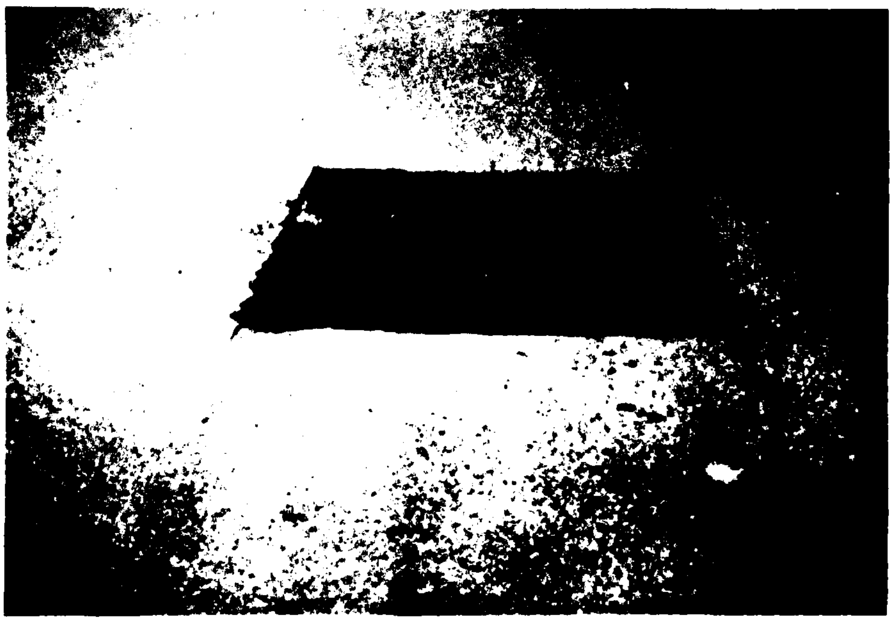

Figure B-46. Light severity patch, flexible pavement, case 2

Figure B-47. Light severity patch with medium severity portion, flexible pavement

Figure B-48. Medium severity patch, flexible pavement

Figure B-49. High severity patch, flexible pavement

POLISHED AGGREGATE -
DISTRESS NO. 11

Description. Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance.

Severity Levels. No degrees of severity are defined. However, the degree of polishing should be significant before it is included in the condition survey and rated as a defect (Figure B-50).

Measuring Procedure. Polished aggregate is measured in square feet of surface area.

RAVELING AND WEATHERING -
DISTRESS NO. 12

Description. Raveling and weathering are the wearing away of the pavement surface caused by the dislodging of aggregate particles and loss of asphalt or tar binder. They may indicate that the asphalt binder has hardened significantly.

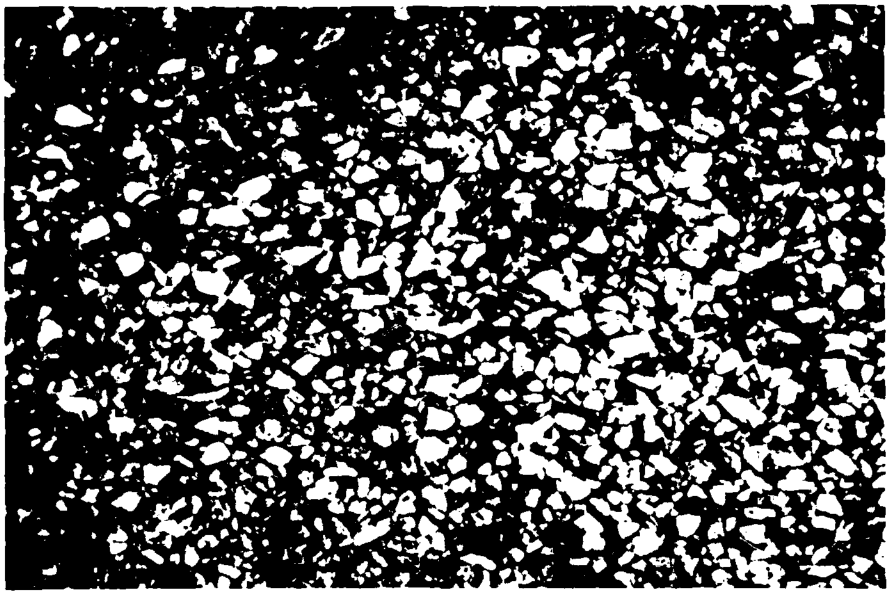

Figure B-50. Polished aggregate

Severity Levels.

a. Low severity level (L). Aggregate or binder has started to wear away with few, if any, loose particles (Figures B-51 through B-53).

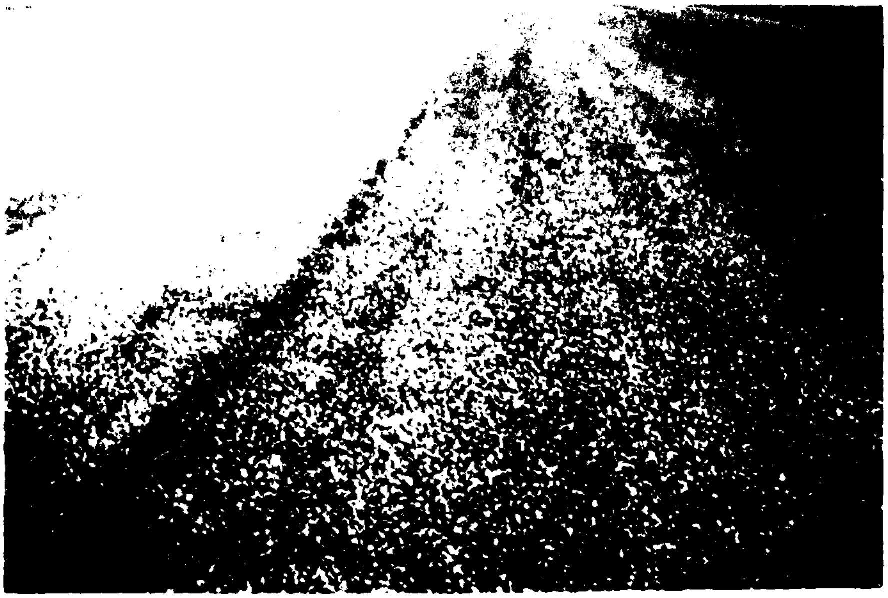

Figure B-51. Light severity raveling/weathering, case 1

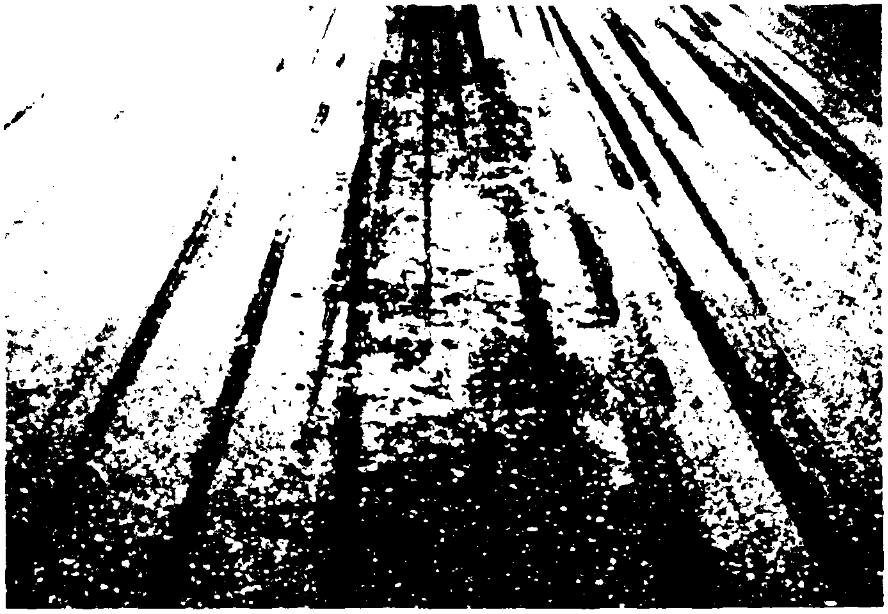

Figure B-52. Light severity raveling/weathering, case 2

Figure B-53. Light severity raveling/weathering, approaching medium severity

b. Medium severity level (M). Aggregate and/or binder has worn away with some loose and missing particles. The surface texture is moderately rough and pitted (Figure B-54).

Figure B-54. Medium severity raveling/weathering

c. High severity level (H). Aggregate and/or binder has worn away with a large amount of loose and missing particles. The surface texture is severely rough and pitted (Figures B-55 and B-56).

Measuring Procedure. Raveling and weathering are measured in square feet of surface area.

RUTTING - DISTRESS NO. 13

Description. A rut is a surface depression in the wheel path. Pavement uplift may occur along the sides of the rut; however, in many instances ruts are noticeable only after a rainfall, when the wheel paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade, usually caused by consolidation

Figure B-55. High severity raveling/weathering, case 1

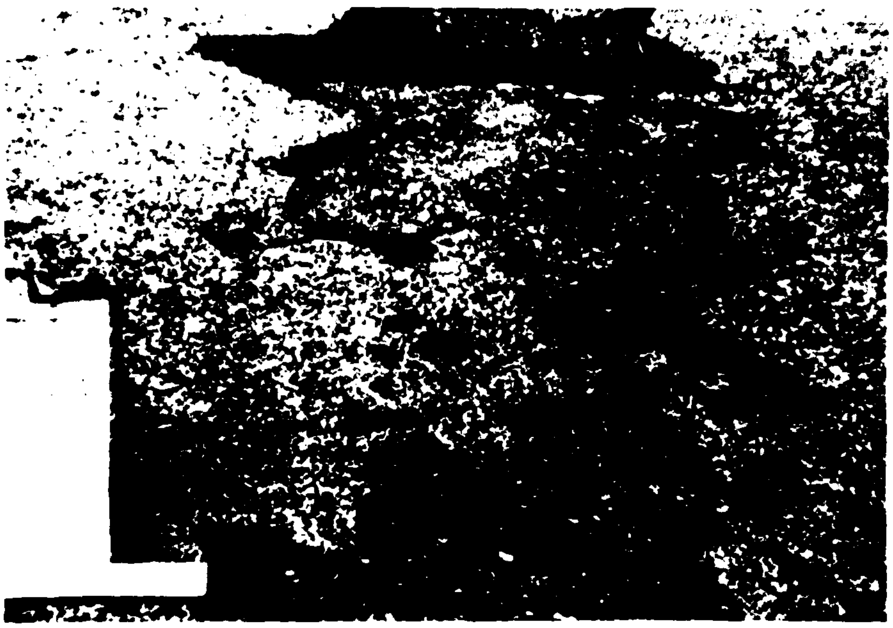

Figure B-56. High severity raveling/weathering, case 2

or lateral movement of the materials due to traffic loads. Significant rutting can lead to major structural failure of the pavement.

Severity Levels.

Mean Rut Depth Criteria

Severity	All Pavement Sections
L	1/4-1/2 in. (Figures B-57 and B-58)
M	>1/2-1 in. (Figure B-59)
H	>1 in. (Figures B-60 and B-61)

Measuring Procedure. Rutting is measured in square feet of surface area, and its severity is determined by the mean depth of the rut. To determine the mean rut depth, a straightedge should be laid across the rut and the depth measured. The mean depth in inches should be computed from measurements taken along the length of the rut.

SHOVING OF ASPHALT PAVEMENT BY PCC SLABS - DISTRESS NO. 14

Description. PCC pavements occasionally increase in length at ends where they adjoin flexible pavements (commonly referred to as "pavement growth"). This "growth" shoves the asphalt- or tar-surfaced pavements, causing them to swell and crack. The PCC slab "growth" is caused by a gradual opening up of the joints as they are filled with incompressible materials that prevent them from reclosing.

Severity Level.

a. Low severity level (L). A slight amount of shoving has occurred with little effect on ride quality and no breakup of the asphalt pavement (Figure B-62).

b. Medium severity level (M). A significant amount of shoving has occurred, causing moderate roughness and little or no breakup of the asphalt pavement (Figure B-62).

c. High severity level (H). A large amount of shoving has occurred, causing severe roughness or breakup of the asphalt pavement (Figure B-63).

Measuring Procedure. Shoving is measured by determining the area in square feet of the swell caused by shoving.

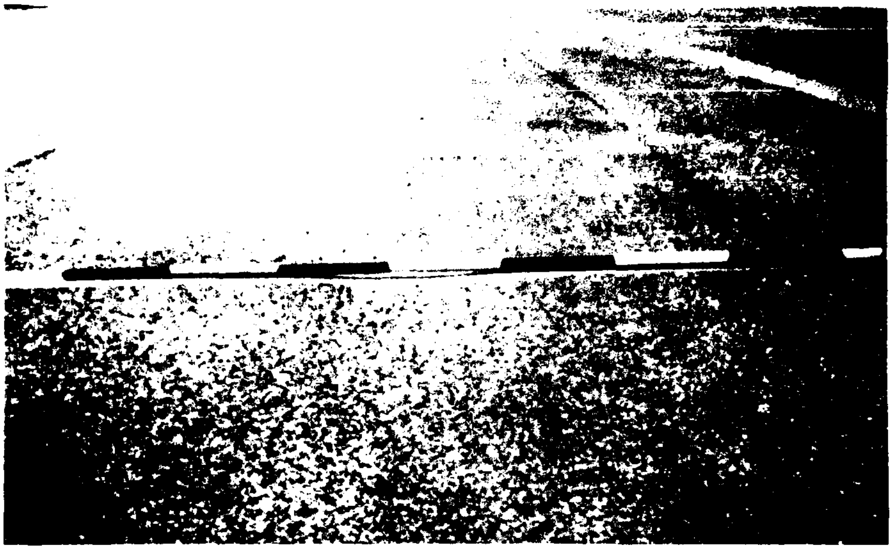

Figure B-57. Light severity rutting, case 1

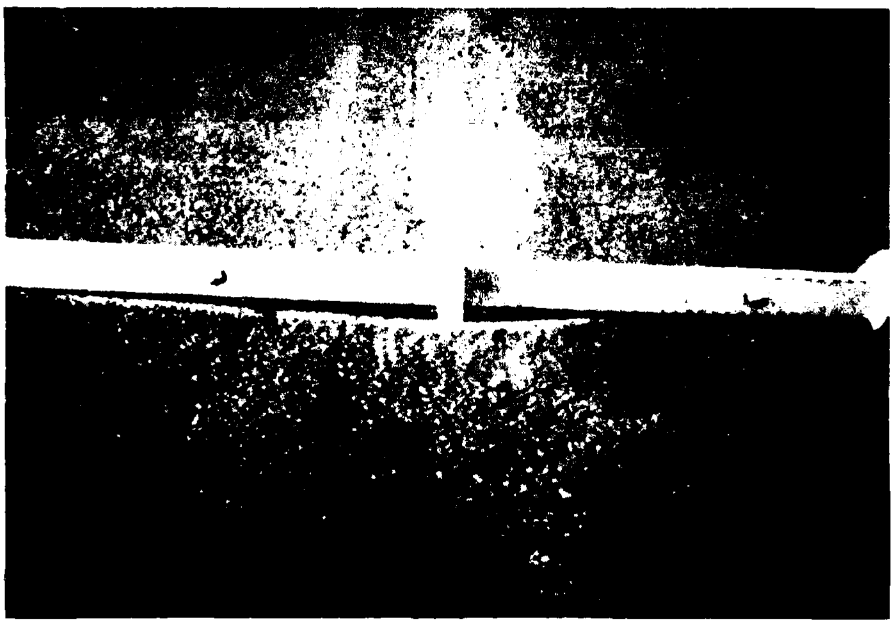

Figure B-58. Light severity rutting, case 2

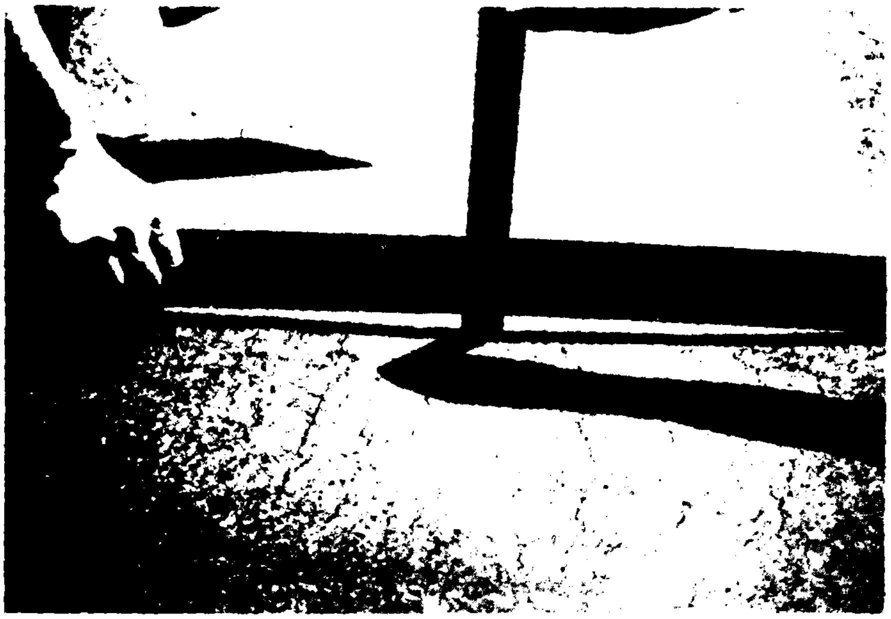

Figure B-59. Medium severity rutting

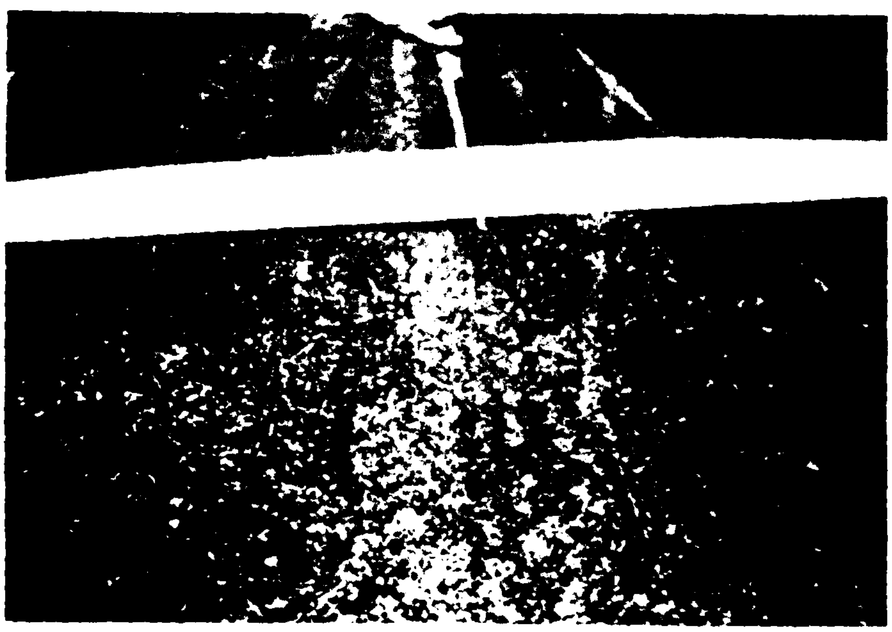

Figure B-60. High severity rutting (Note alligator cracking associated with rutting.)

Figure B-61. High severity rutting (Note cracking and upheaval on sides of rut.)

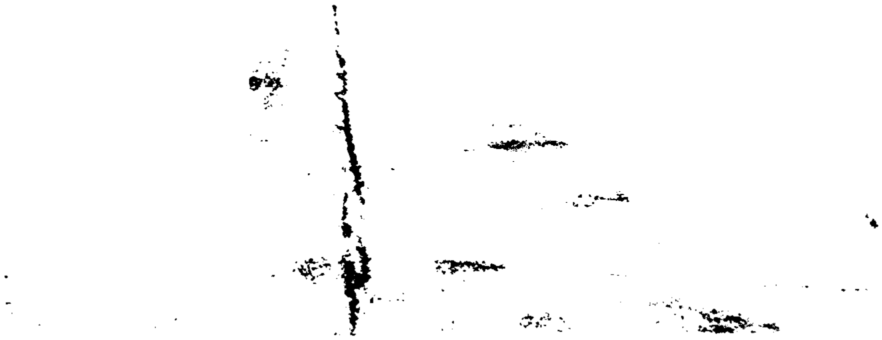

Figure B-62. Low severity shove on the outside and medium severity in the middle

Figure B-63. High severity shoving

SLIPPAGE CRACKING -
DISTRESS NO. 15

Description. Slippage cracks are crescent- or half-moon-shaped cracks having two ends pointed away from the direction of traffic. They are produced when braking or turning wheels cause the pavement surface to slide and deform. This usually occurs when there is a low strength surface mix or poor bond between the surface and next layer of pavement structure.

Severity Levels. No degrees of severity are defined. It is sufficient to indicate that a slippage crack exists (Figures B-64 and B-65).

Measuring Procedure. Slippage cracking is measured in square feet of surface area.

SWELL - DISTRESS NO. 16

Description. Swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil, but a small swell can also occur on the surface of an asphalt overlay (over PCC) as a result of a blowup in the PCC slab.

Severity Levels.

a. Low severity level (L). Swell is barely visible and has a minor effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration. (Low severity swells may not always be observable, but their existence can be confirmed by driving a vehicle over the section at the normal aircraft speed. An upward acceleration will occur if the swell is present.) (Figure B-66).

b. Medium severity level (M). Swell can be observed without difficulty and has a significant effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration (Figure B-67).

c. High severity level (H). Swell can be readily observed and severely affects the pavement's ride quality at the normal aircraft speed for the pavement section under consideration (Figures B-68 and B-69).

Figure B-64. Slippage cracking, case 1

Figure B-65. Slippage cracking, case 2

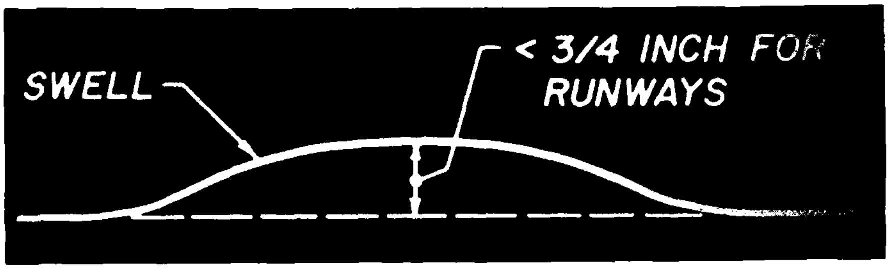

Figure B-66. Low severity swell

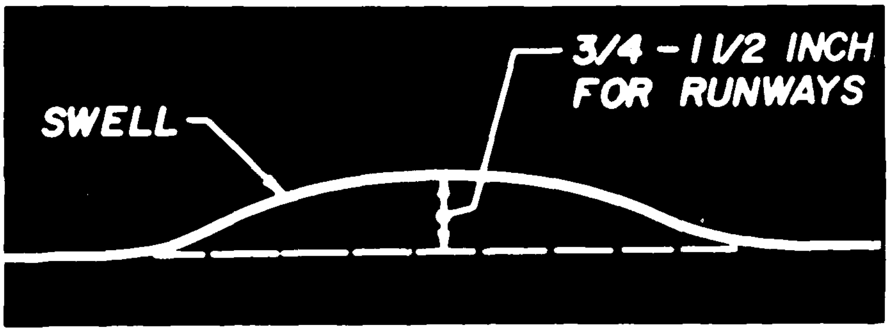

Figure B-67. Medium severity swell

Figure B-68. High severity swell

Figure B-69. High severity sharp swell

Measuring Procedure. The surface area of the swell is measured in square feet. The severity rating should consider the type of pavement section (i.e., runway, taxiway, or apron). For example, a swell of sufficient magnitude to cause considerable roughness on a runway at high speeds would be rated as more severe than the same swell located on an apron or taxiway where the normal aircraft operating speeds are much lower. The following guidance is provided for runways:

Severity	Height Differential
L	< 3/4 in.
M	3/4 - 1-1/2 in.
H	>1-1/2 in.

DISTRESSES ON JOINTED RIGID PAVEMENTS

BLOWUP - DISTRESS NO. 1

Description. Blowups occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. The insufficient width is usually caused by infiltration

of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups can also occur at utility cuts and drainage inlets. This type of distress is almost always repaired immediately because of severe damage potential to aircraft. The main reason blowups are included here is for reference when closed sections are being evaluated for reopening.

Severity Levels.

a. Low severity level (L). Buckling or shattering has not rendered the pavement inoperative, and only a slight amount of roughness exists (Figure B-70).

b. Medium severity level (M). Buckling or shattering has not rendered the pavement inoperative, but a significant amount of rougness exists (Figure B-71).

c. High severity level (H). Buckling or shattering has rendered the pavement inoperative (Figure B-72).

For the pavement to be considered operational, all foreign material caused by the blowup must have been removed.

Counting Procedure. A blowup usually occurs at a transverse crack or joint. At a crack, it is counted as being in one slab, but at a joint two slabs are affected and the distress should be recorded as occurring in two slabs.

CORNER BREAK - DISTRESS NO. 2

Description. A corner break is a crack that intersects the joints at a distance less than or equal to one-half of the slab length on both sides, measured from the corner of the slab. For example, a slab with dimensions of 25 by 25 ft that has a crack intersecting the joint 5 ft from the corner on one side and 17 ft on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 7 ft on one side and 10 ft on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, while a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses usually cause corner breaks.

Figure B-70. Low severity blowup (Note that this would only be considered low severity if the shattering in the foreground was the only part existing and the foreign material removed.)

Figure B-71. Medium severity blowup

Figure B-72. High severity blowup

Severity Levels.

a. Low severity level (L). Crack has little or no spalling with no loose particles. If nonfilled, it has a mean width less than approximately 1/8 in. A filled crack can be of any width, but the filler material must be in satisfactory condition. The area between the corner break and the joints is not cracked (Figures B-73 and B-74).

b. Medium severity joint (M). One of the following conditions exists:

(1) Filled or nonfilled crack is moderately spalled with some loose particles.

(2) A nonfilled crack has a mean width between 1/8 and 1 in.

(3) A filled crack is not spalled or only lightly spalled, but the filler is in unsatisfactory condition.

(4) The area between the corner break and the joints is lightly cracked (Figures B-75 and B-76).

c. High severity level (H). One of the following conditions exists:

(1) Filled or nonfilled crack is severely spalled with loose and missing particles.

(2) A nonfilled crack has a mean width greater than approximately 1 in., creating a tire damage potential.

Figure B-73. Low severity corner break, case 1

Figure B-74. Low severity corner break, case 2

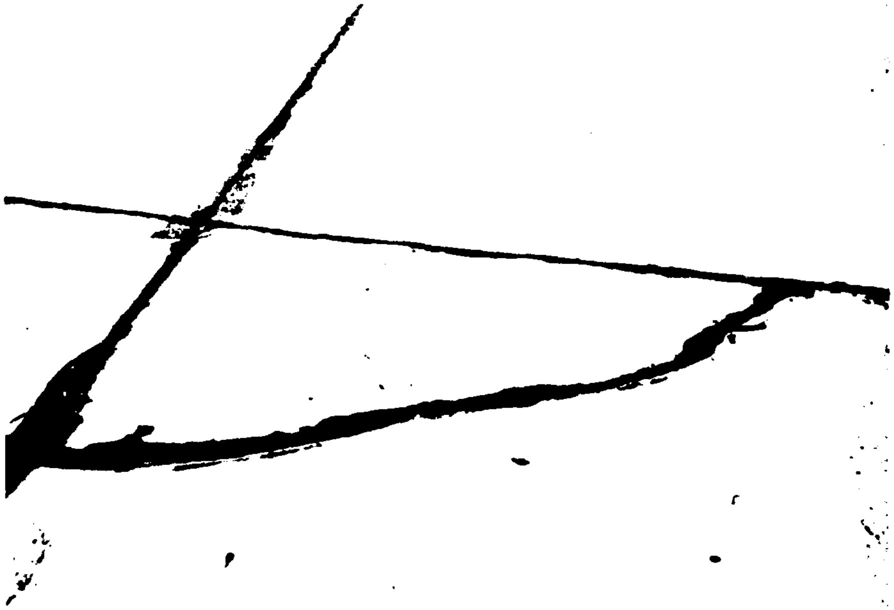

Figure B-75. Medium severity corner break, case 1
(Area between the corner break and the joint is
lightly cracked.)

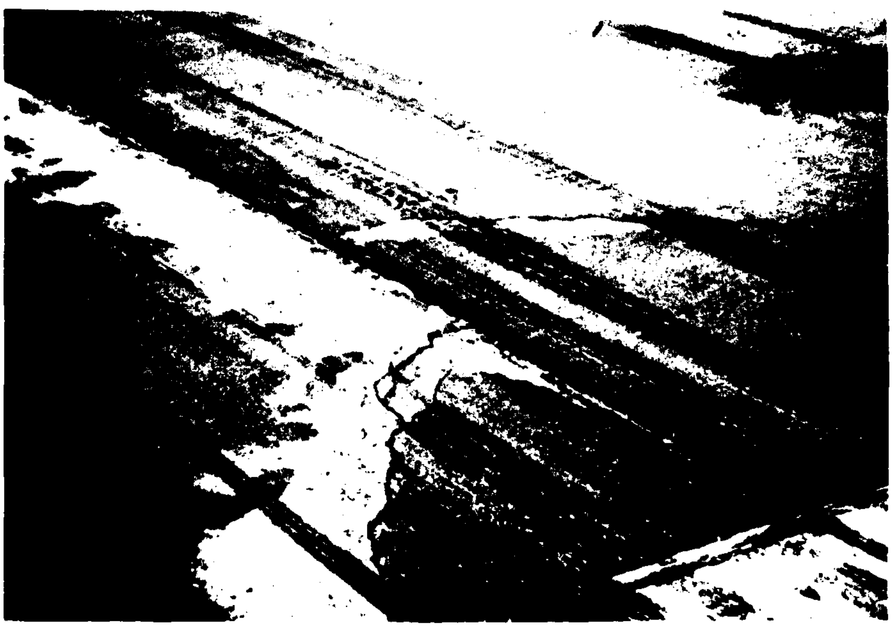

Figure B-76. Medium severity corner break, case 2

(3) The area between the corner break and the joints is severely cracked (Figure B-77).

Figure B-77. High severity corner break

Counting Procedure. A distress slab is recorded as one slab if it (a) contains a single corner break, (b) contains more than one break of a particular severity, or (c) contains two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both light and medium severity corner breaks should be counted as one slab with a medium corner break.

LONGITUDINAL, TRANSVERSE, AND
DIAGONAL CRACKS - DISTRESS NO. 3

Description. These cracks, which divide the slab into two or three pieces, are usually caused by a combination of load repetition, curling stresses, and shrinkage stresses. (For slabs divided into six or more pieces, see shattered/intersecting cracks.) Low severity cracks are usually warping- or friction-related and are not considered major structural distresses. Medium or high severity cracks are usually working cracks and are considered major structural distresses. (NOTE:

Hairline cracks that are only a few feet long and do not extend across the entire slab are rated as shrinkage cracks.)

Severity Levels.

a. Low severity level (L). Cracks have little or no spalling with no loose particles. If nonfilled, it is less than 1/8 in. wide. A filled crack can be of any width, but its filler material must be in satisfactory condition (Figures B-78 through B-80).

b. Medium severity level (M). One of the following conditions exists:

(1) A filled or nonfilled crack is moderately spalled with some loose or missing particles.

(2) A nonfilled crack has a mean width between 1/8 and 1 in.

(3) A filled crack has no spalling or minor spalling, but the filler is in unsatisfactory condition.

(4) The slab is divided into three pieces by low severity cracks (Figures B-81 through B-83).

c. High severity level (H). One of the following conditions exists:

(1) A filled or nonfilled crack is severely spalled with loose and missing particles.

(2) A nonfilled crack has a mean width approximately greater than 1 in., creating tire damage potential.

(3) The slab is divided into three pieces by two or more cracks, one of which is at least of medium severity (Figures B-84 through B-86).

Counting Procedure. Once the severity has been identified, the distress is recorded as one slab.

DURABILITY ("D") CRACKING -
DISTRESS NO. 4

Description. Durability cracking is caused by the concrete's inability to withstand environmental factors such as freeze-thaw cycles. It usually appears as a pattern of cracks running parallel to a joint or linear crack. A dark coloring can usually be seen around the fine durability cracks. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 ft of the joint or crack.

Figure B-78. Low severity longitudinal crack, jointed rigid pavement

Figure B-79. Low severity filled longitudinal cracks, jointed rigid pavement

Figure B-80. Low severity diagonal crack, jointed rigid pavement

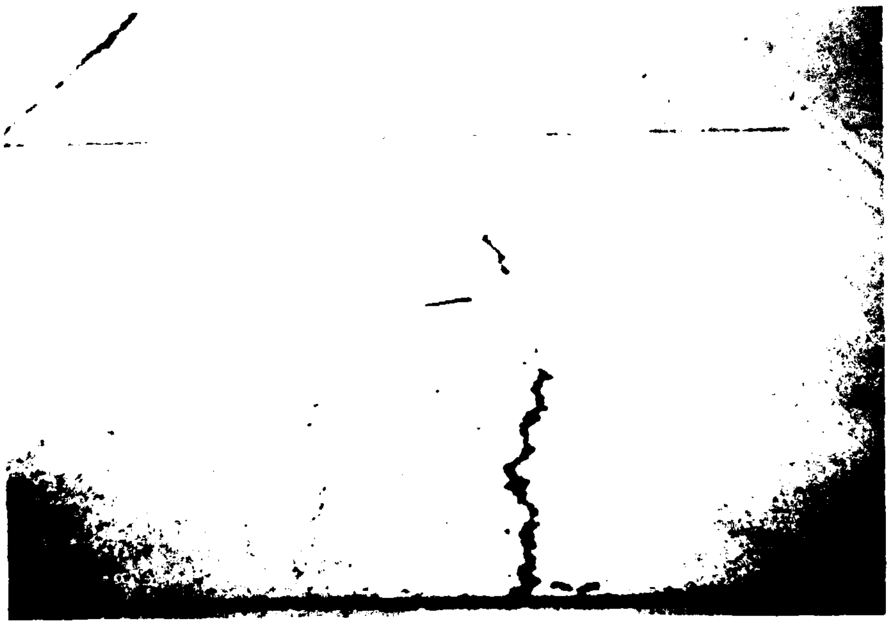

Figure B-81. Medium severity longitudinal crack, jointed rigid pavement

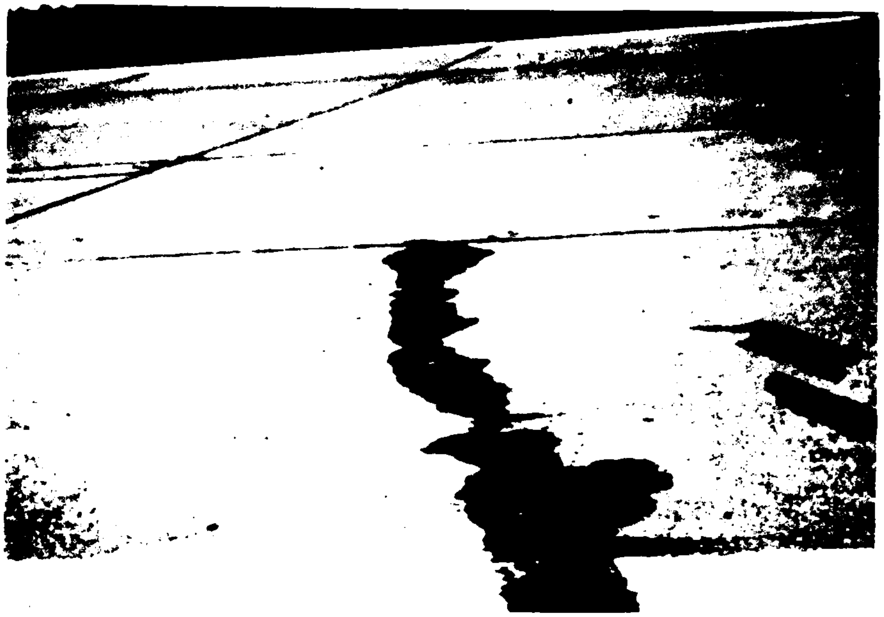

Figure B-82. Medium severity transverse crack, jointed rigid pavement, case 1

Figure B-83. Medium severity transverse crack, jointed rigid pavement, case 2

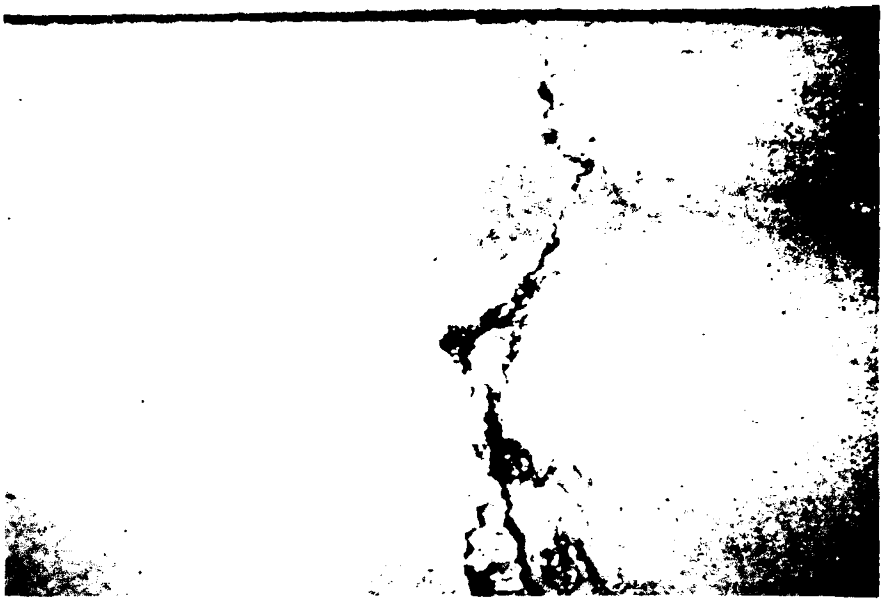

Figure B-84. High severity transverse crack, jointed rigid pavement

Figure B-85. High severity longitudinal crack, jointed rigid pavemenc, case 1

Figure B-86. High severity longitudinal crack, jointed rigid pavement, case 2

Severity Levels

a. Low severity level (L). Pieces are defined by light cracks and cannot be removed (Figure B-87).

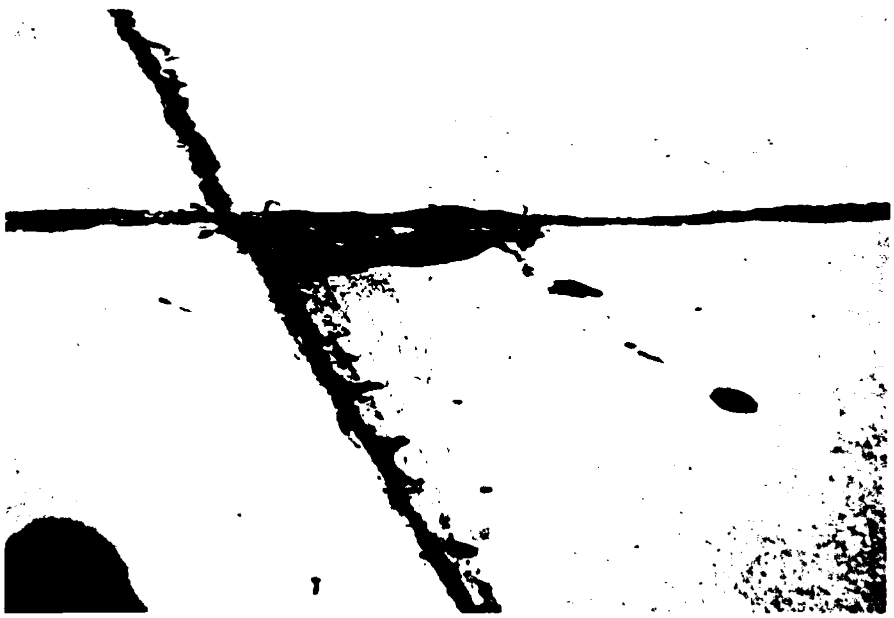

Figure B-87. Low severity "D" cracking

b. <u>Medium severity level (M)</u>. "D" cracks are well defined. Small pieces have been displaced (Figures B-88 and B-89).

Figure B-88. Medium severity "D" cracking, case 1

Figure B-89. Medium severity "D" cracking, case 2

c. <u>High severity level (H)</u>. "D" cracking has developed over a considerable amount of slab area (greater than approximately one-quarter of the slab area), and the pieces are well defined and can be removed easily (Figure B-90).

Figure B-90. High severity "D" cracking (This condition exists over more than one-quarter of the slab.)

<u>Counting Procedure</u>. When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level is found, the slab is counted as having the higher severity distress. For example, if light and medium durability cracking are located on one slab, the slab is counted as having medium only.

JOINT SEAL DAMAGE -
DISTRESS NO. 5

<u>Description</u>.

a. Joint seal damage is any condition which enables soil or rocks to accumulate in the joints or allows significant infiltration of water. Accumulation of incompressible materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from accumulation of materials

and also prevents water from seeping down and softening the foundation supporting the slab.

b. Typical types of joint seal damage are: stripping of joint sealant, extrusion of joint sealant, weed growth, hardening of the filler (oxidation), loss of bond to the slab edges, and lack or absence of sealant in the joint.

Severity Levels.

a. Low severity level (L). Joint sealer is in generally good condition throughout the section. Sealant is performing well with only a minor amount of any of the above types of damage present (Figure B-91).

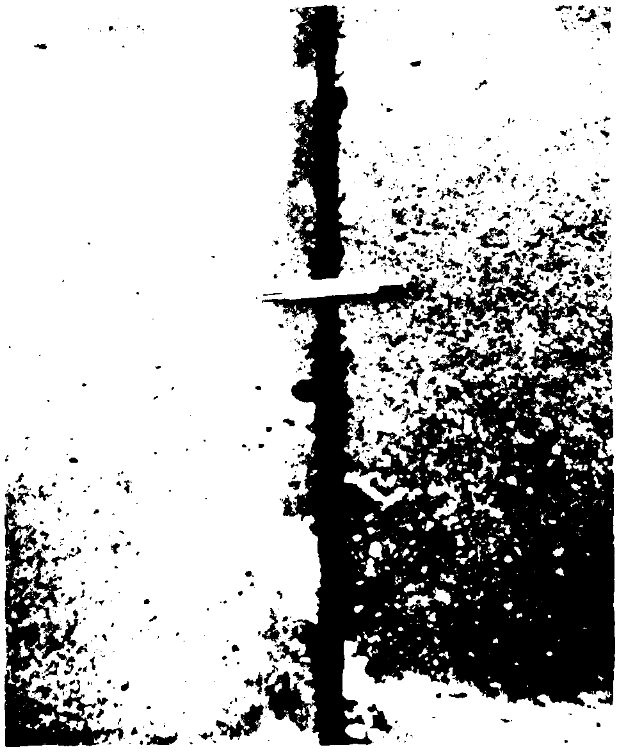

Figure B-91. Light severity joint seal damage (This condition existed only on a few joints in the pavement section. If all joint sealant were as shown, it would have been rated medium.)

b. Medium severity level (M). Joint sealer is in generally fair condition over the entire surveyed section with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within 2 years (Figure B-92).

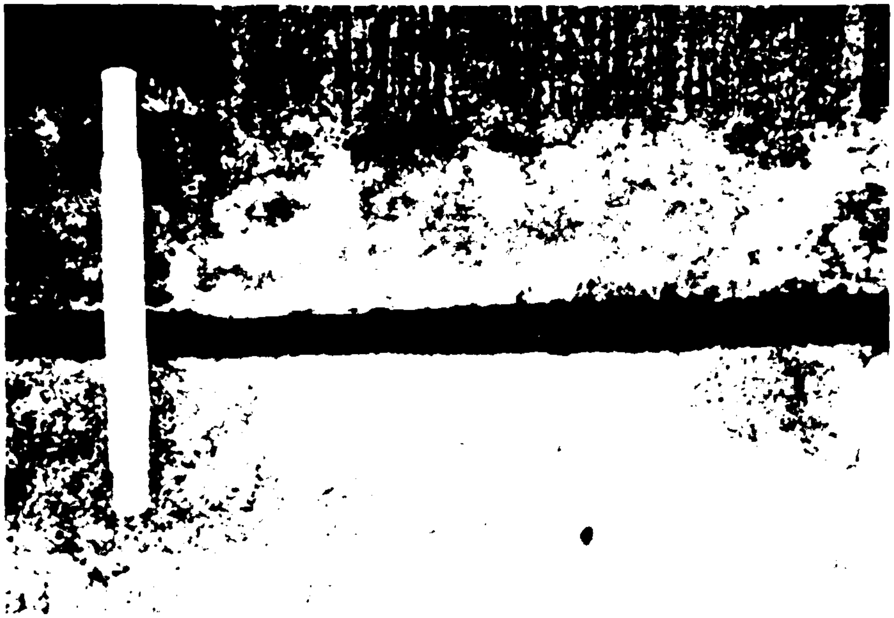

Figure B-92. Medium severity joint seal damage (Note that sealant has lost bond and is highly oxidized.)

c. High severity level (H). Joint sealer is in generally poor condition over the entire surveyed section with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement (Figures B-93 and B-94).

Counting Procedure. Joint seal damage is not counted on a slab-by-slab basis, but is rated based on the overall condition of the sealant over the entire section.

PATCHING, SMALL (LESS THAN 5 SQ FT) - DISTRESS NO. 6

Description. A patch is an area where the original pavement has been removed and replaced by a filler material. For condition evaluation, patching is divided into two types: small (less than 5 sq ft) and large (over 5 sq ft). Large patches are described in the next section.

Severity Levels.

a. Low severity level (L). Patch is functioning well with little or no deterioration (Figures B-95 and B-96).

b. Medium severity level (M). Patch has deteriorated and/or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort (Figures B-97 and B-98).

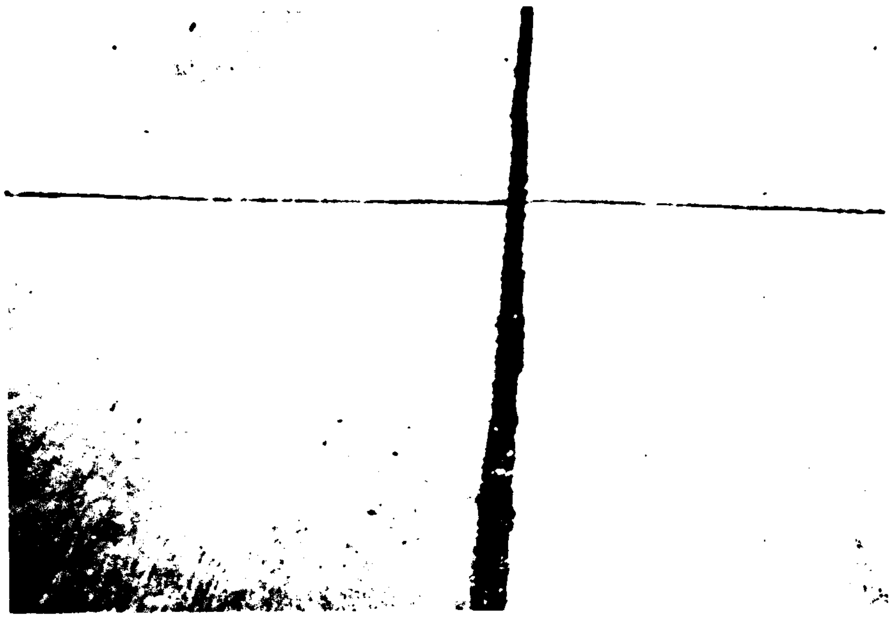

Figure B-93. High severity joint seal damage (complete loss of sealant; joint is filled with incompressible material)

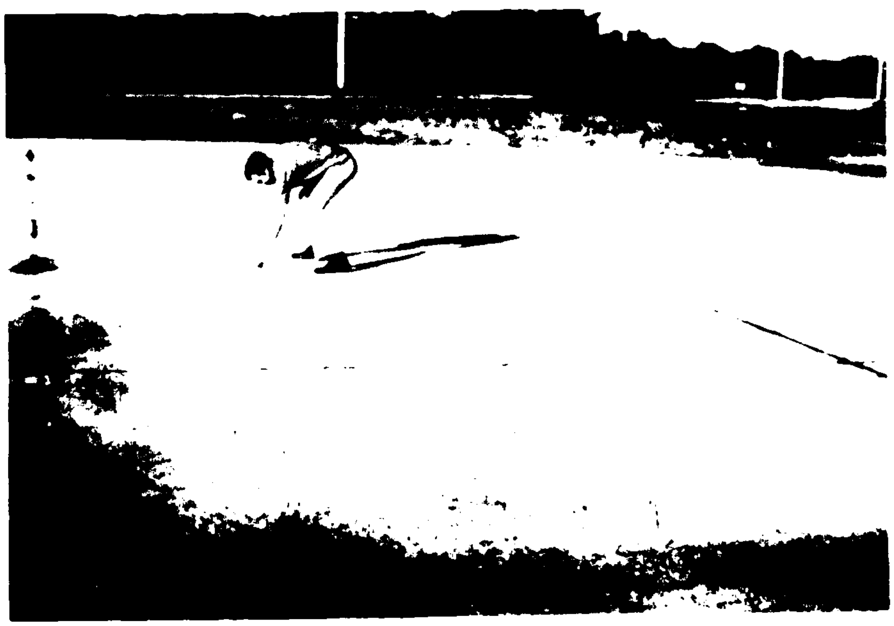

Figure B-94. High severity joint seal damage (extensive amount of weed growth)

Figure B-95. Low severity small patch,
jointed rigid pavement, case 1

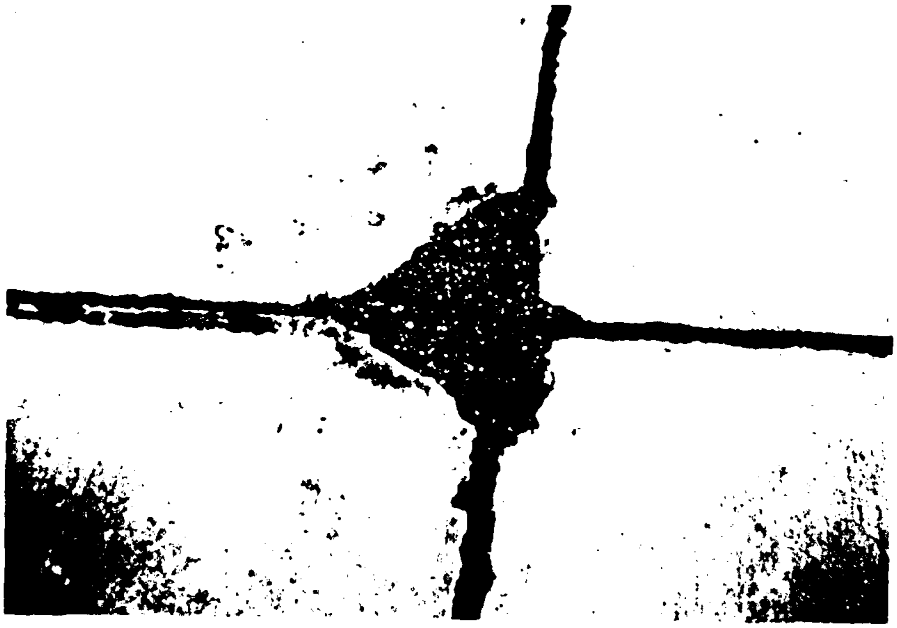

Figure B-96. Low severity small patch,
jointed rigid pavement, case 2

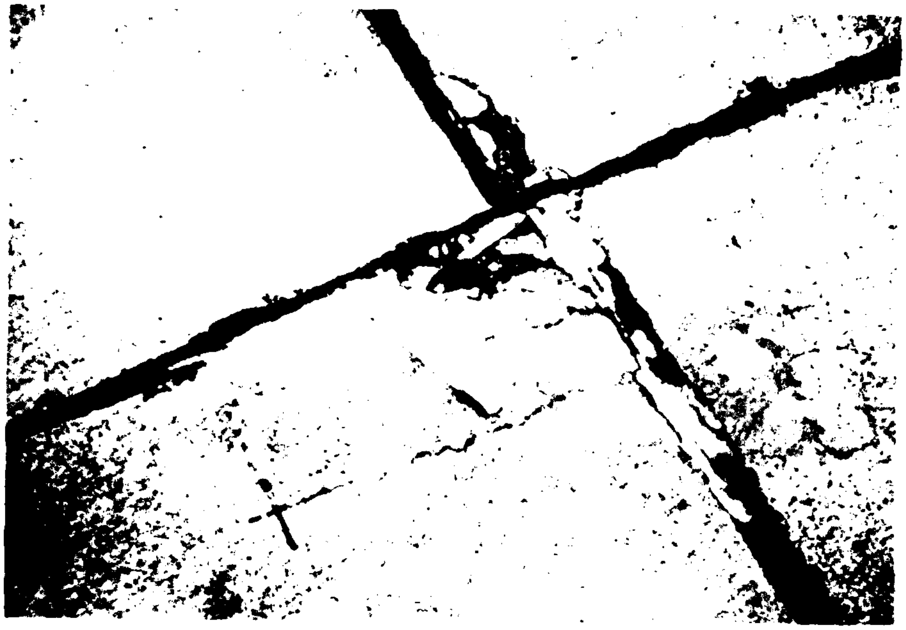

Figure B-97. Medium severity small patch, jointed rigid pavement, case 1

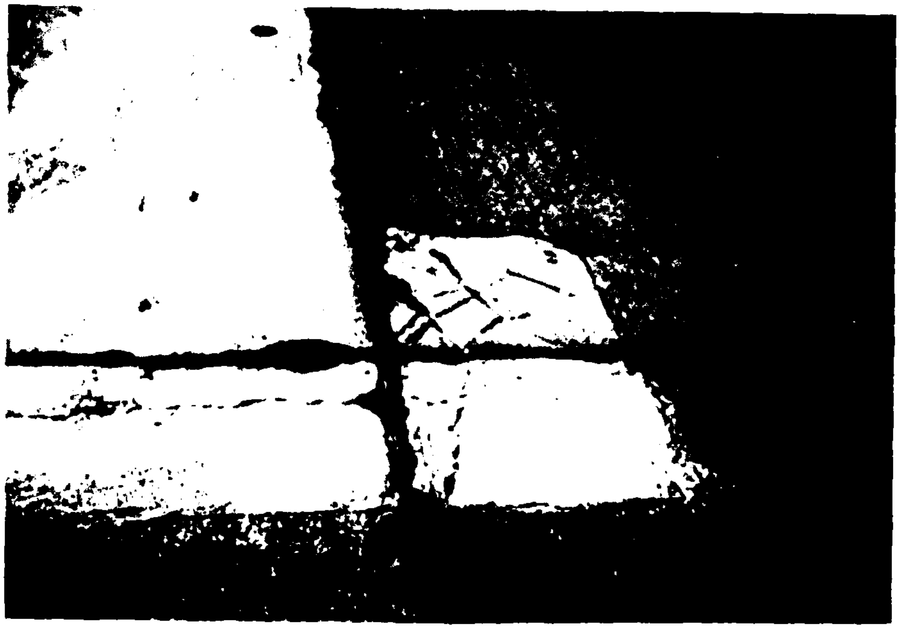

Figure B-98. Medium severity small patch, jointed rigid pavement, case 2

c. High severity level (H). Patch has deteriorated, either by spalling around the patch or cracking within the patch, to a state which warrants replacement (Figure B-99).

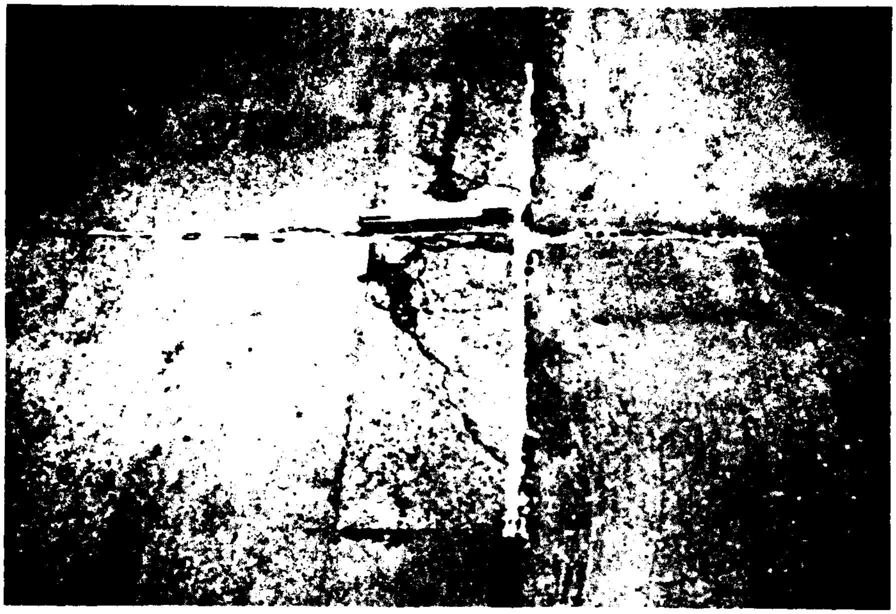

Figure B-99. High severity small patch, jointed rigid pavement

Counting Procedure. If one or more small patches having the same severity level are located in a slab, it is counted as one slab containing that distress. If more than one severity level occurs, it is counted as one slab with the higher severity level being recorded.

PATCHING, LARGE (OVER 5 SQ FT)
AND UTILITY CUT - DISTRESS NO. 7

Description. Patching is the same as defined in the previous section. A utility cut is a patch that has replaced the original pavement because of placement of underground utilities. The severity levels of a utility cut are the same as those for regular patching.

Severity Levels.

a. Low severity level (L). Patch is functioning well with very little or no deterioration (Figures B-100 through B-102).

b. Medium severity level (M). Patch is deteriorated and/or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort (Figure B-103).

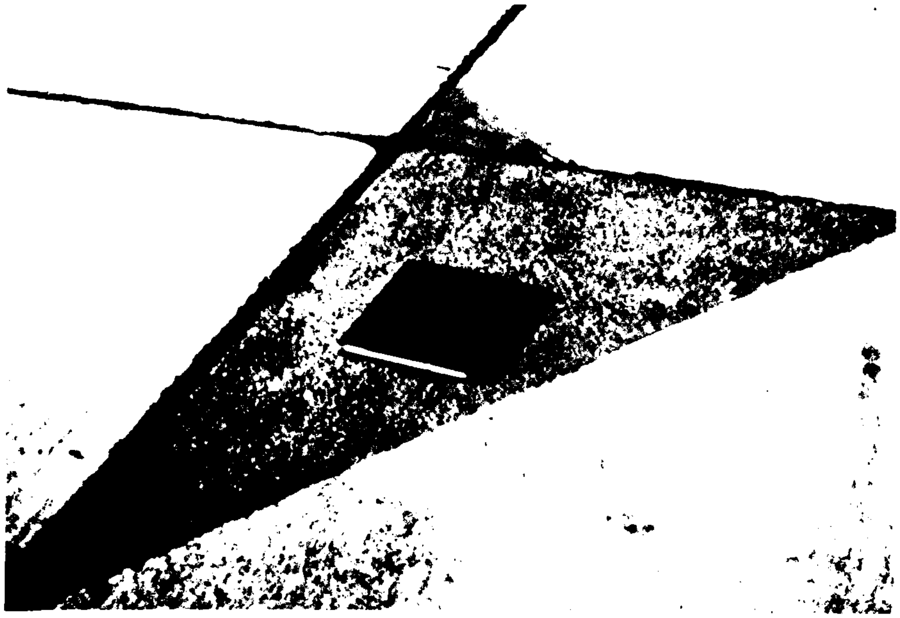

Figure B-100. Low severity patch, jointed rigid pavement, case 1

Figure B-101. Low severity patch, jointed rigid pavement, case 2

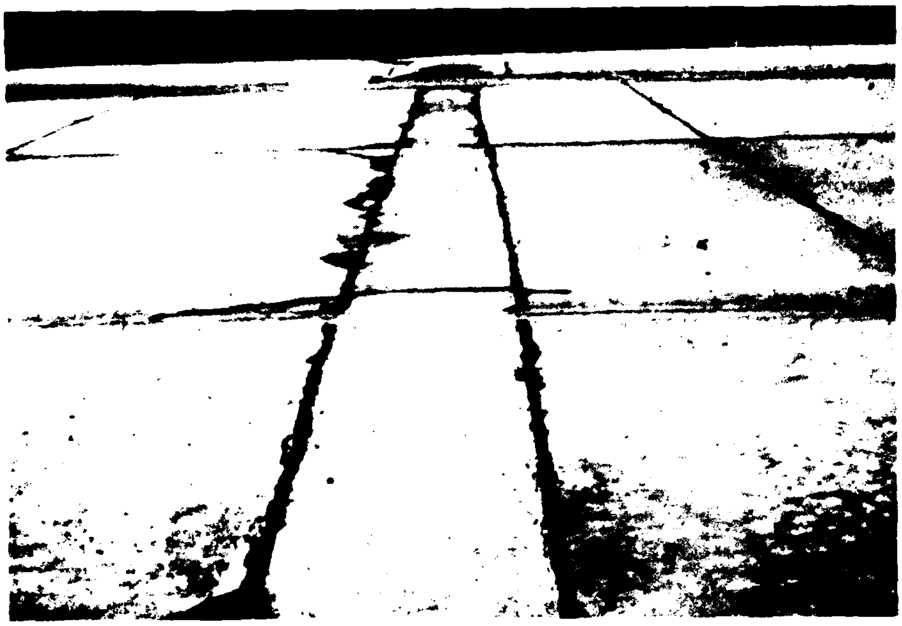

Figure B-102. Low severity utility cut

Figure B-103. Medium severity utility cut

c. High severity level (H). Patch has deteriorated to a state which causes considerable roughness with loose or easily dislodged material. The extent of the deterioration warrants replacement of the patch (Figure B-104).

Figure B-104. High severity patch, jointed rigid pavement

Counting Procedure. The criteria are the same as for small patches.

POPOUTS - DISTRESS NO. 8

Description. A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 1 to 4 in. in diameter and from 1/2 to 2 in. deep.

Severity Levels. No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress; i.e., average popout density must exceed approximately three popouts per square yard over the entire slab area (Figure B-105).

Counting Procedure. The density of the distress must be measured. If there is any doubt about the average being greater than three popouts per square yard, at least three random 1-sq-yd areas should be

checked. When the average is greater than this density, the slab is counted.

Figure B-105. Popouts

PUMPING - DISTRESS NO. 9

Description. Pumping is the ejection of material by water through joints or cracks caused by deflection of the slab under passing loads. As the water is ejected, it carries particles of gravel, sand, clay, or silt resulting in a progressive loss of pavement support. Surface staining and base or subgrade material on the pavement close to joints or cracks are evidence of pumping. Pumping near joints indicates poor joint sealer and loss of support, which will lead to cracking under repeated loads.

Severity Levels. No degrees of severity are defined. It is sufficient to indicate the pumping exists (Figures B-106 through B-109).

Counting Procedure. Slabs are counted as follows (Figure B-110): one pumping joint between two slabs is counted as two slabs. However, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.

Figure B-106. Pumping (Note fine material on surface that has been pumped out causing corner break.)

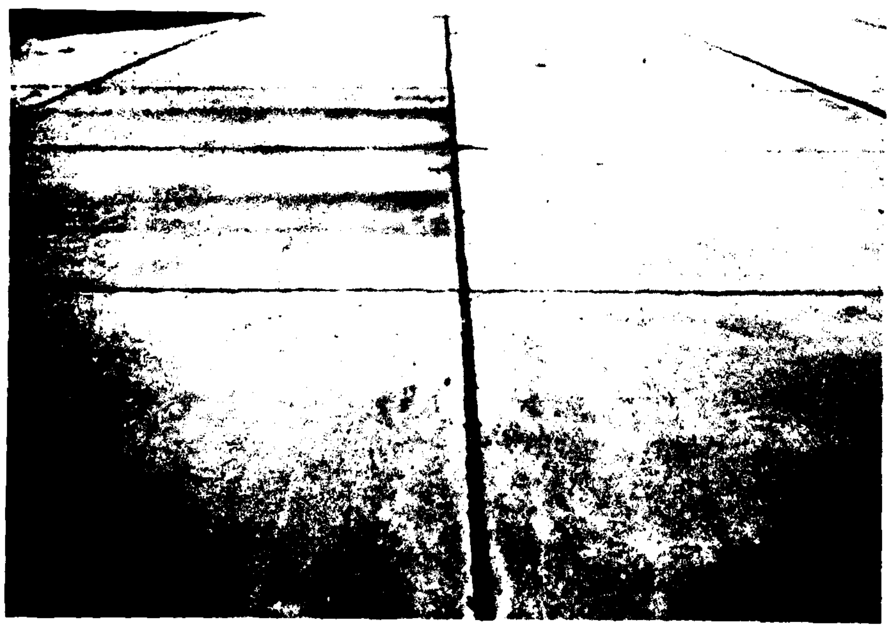

Figure B-107. Pumping (Note stains on pavement.)

Figure B-108. Pumping (close-up of fine materials collecting in the joint)

Figure B-109. Pumping

two slabs counted three slabs counted five slabs counted

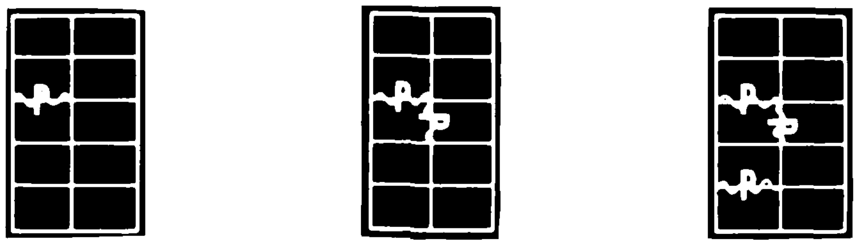

Figure B-110. Counting procedure for pumping

SCALING, MAP CRACKING, AND
CRAZING - DISTRESS NO. 10

Description. Map cracking or crazing refers to a network of shallow, fine, or hairline cracks that extend only through the upper surface of the concrete. The cracks tend to intersect at angles of 120 degrees. Map cracking or crazing is usually caused by overfinishing the concrete and may lead to scaling of the surface, which is the breakdown of the slab surface to a depth of approximately 1/4 to 1/2 in. Scaling may also be caused by deicing salts, improper construction, freeze-thaw cycles, and poor aggregate. Another recognized source of distress is the reaction between the alkalies (Na_2O and K_2O) in some cements and certain minerals in some aggregates. Products formed by the reaction between the alkalies and aggregate result in expansions that cause a breakdown in the concrete. This generally occurs throughout the slab and not just at joints where "D" cracking normally occurs.

Severity Levels.

a. Low severity level (L). Crazing or map cracking exists over most of the slab area. The surface is in good condition with no scaling (Figure B-111). Note: The low severity level is an indicator that scaling may develop in the future.

b. Medium severity level (M). Slab is scaled over approximately 5 percent or less of the surface with some loose or missing material (Figure B-112).

c. High severity level (H). Slab is severely scaled with a large amount of loose or missing material. Usually, more than 5 percent of the surface is affected (Figures B-113 and B-114).

Figure B-111. Low severity crazing

Figure B-112. Medium severity scaling

Figure B-113. High severity scaling

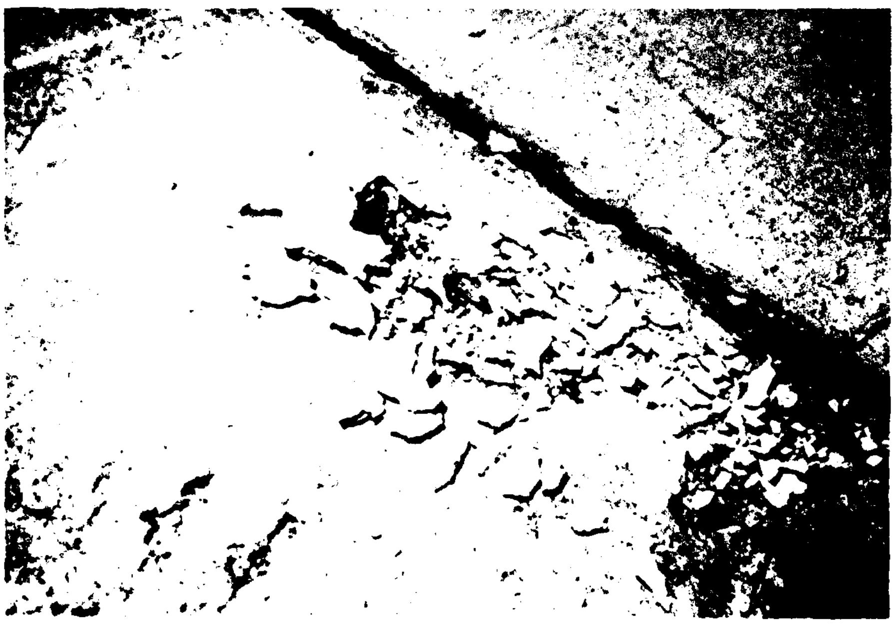

Figure B-114. Close-up of high severity scaling

Counting Procedure. If two or more levels of severity exist on a slab, the slab is counted as one slab having the maximum level of severity. For example, if both low severity crazing and medium scaling exist on one slab, the slab is counted as one slab containing medium scaling.

SETTLEMENT OR FAULTING -
DISTRESS NO. 11

Description. Settlement or faulting is a difference of elevation at a joint or crack caused by upheaval or consolidation.

Severity Levels. Severity levels are defined by the difference in elevation across the fault and the associated decrease in ride quality and safety as severity increases.

Difference in Elevation

	Runways/Taxiways	Aprons
L	< 1/4 in.	1/8 ≤ 1/2 in. (Figures B-115 and B-116)
M	1/4-1/2 in.	1/2-1 in. (Figure B-117)
H	> 1/2 in. (Figures B-118 and B-119)	> 1 in.

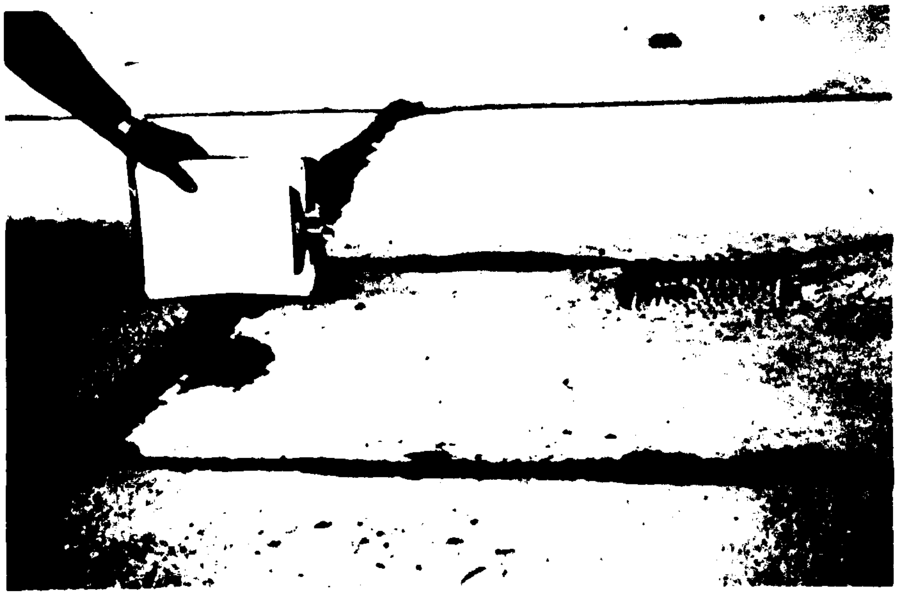

Figure B-115. Low severity settlement (3/8 in.) on apron, case 1

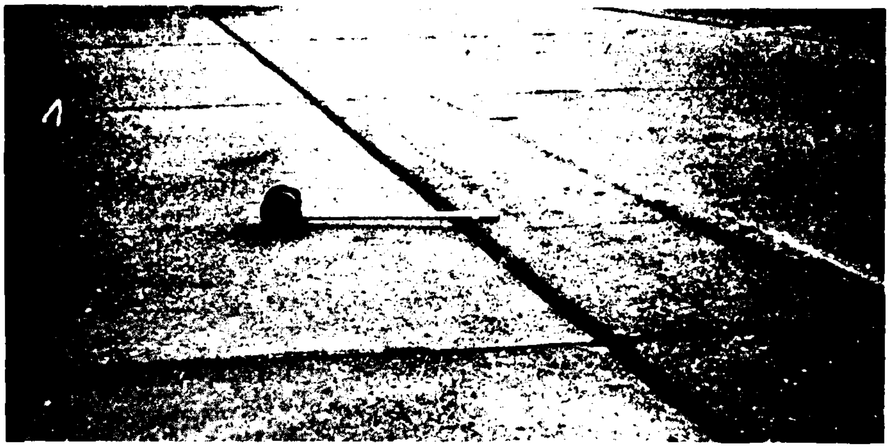

Figure B-116. Low severity settlement on apron, case 2

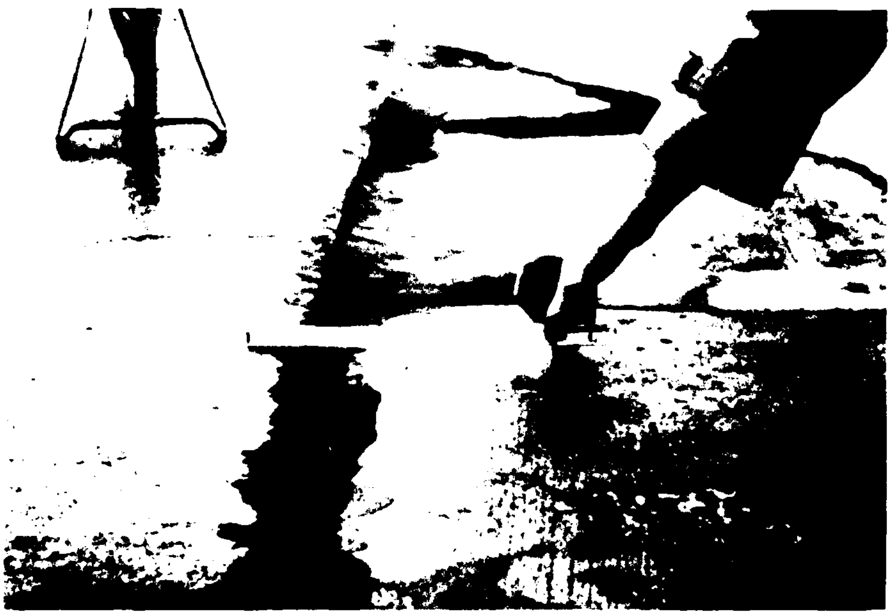

Figure B-117. Medium severity settlement on apron (> 1/2 in.)

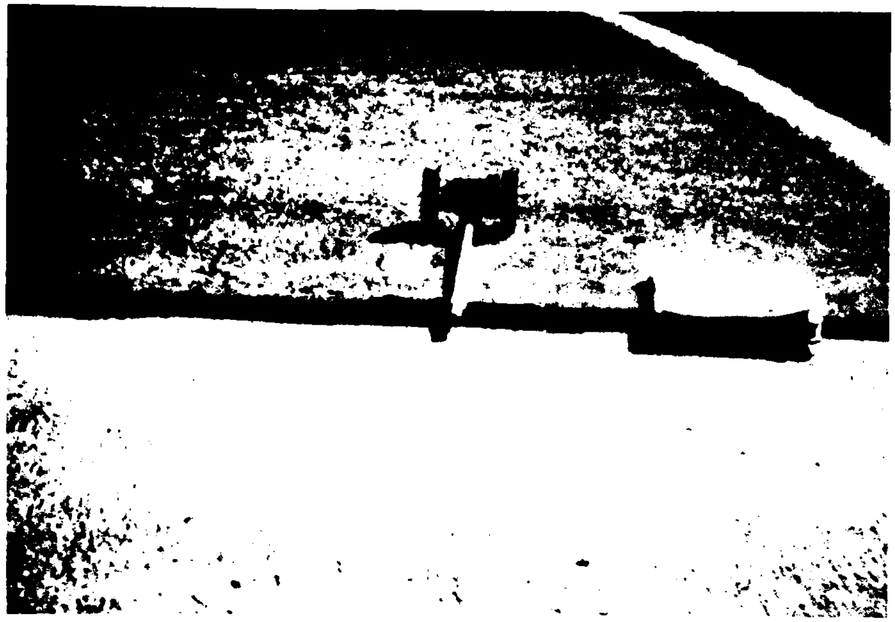

Figure B-118. High severity settlement on taxiway/runway (3/4 in.), case 1

Figure B-119. High severity settlement, case 2

Counting Procedure. In counting settlement, a fault between two slabs is counted as one slab (Figure B-120). A straightedge or level should be used to aid in measuring the difference in elevation between the two slabs (Figure B-117).

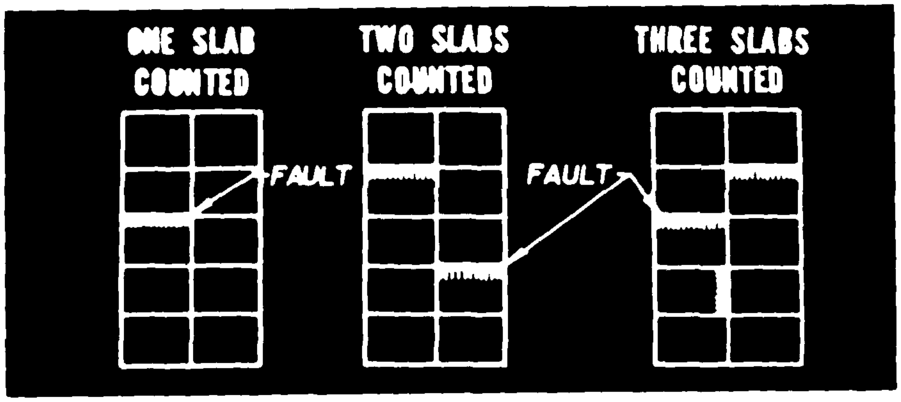

Figure B-120. Counting procedure for settlement or faulting

SHATTERED SLAB/INTERSECTING CRACKS - DISTRESS NO. 12

Description. Intersecting cracks are cracks that break the slab into four or more pieces due to overloading and/or inadequate support. The high severity level of this distress type, as defined below, is referred to as shattered slab. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

Severity Levels.

a. Low severity level (L). Slab is broken into four or five pieces with some or all cracks of low severity (Figures B-121 and B-122).

b. Medium severity level (M).

(1) Slab is broken into four or five pieces with some or all cracks of medium severity (no high severity cracks).

(2) Slab is broken into six or more pieces with all cracks of low severity (Figures B-123 and B-124).

c. High severity level (H). At this level of severity, the slab is called shattered.

Figure B-121. Low severity intersecting cracks, case 1

Figure B-122. Low severity intersecting cracks, case 2

Figure B-123. Medium severity intersecting cracks, case 1

Figure B-124. Medium severity intersecting cracks, case 2

(1) Slab is broken into four or five pieces with some or all cracks of high severity.

(2) Slab is broken into six or more pieces with some or all cracks of medium or high severity (Figure B-125).

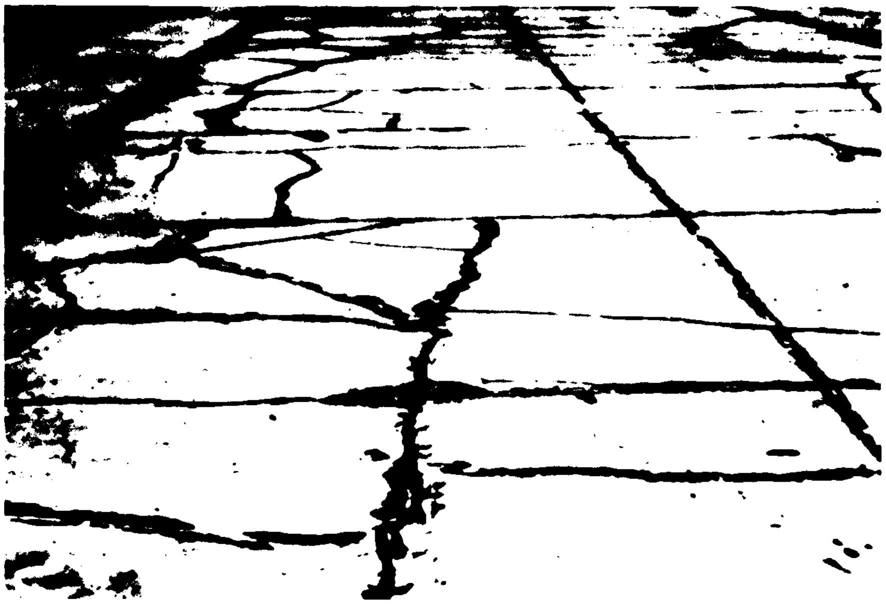

Figure B-125. Shattered slab

Counting Procedure. If a slab is rated as medium or high severity level shattered slab, then no other distress type should be counted in the slab. The deduct values for shattered slab distress are high since this condition is essentially failure; therefore, the counting of other distress types in the slab would tend to underrate the PCI of the sample unit.

SHRINKAGE CRACKS - DISTRESS NO. 13

Description. Shrinkage cracks are hairline cracks that are usually only a few feet long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

Severity Levels. No degrees of severity are defined. It is sufficient to indicate that shrinkage cracks exist (Figures B-126 through B-128).

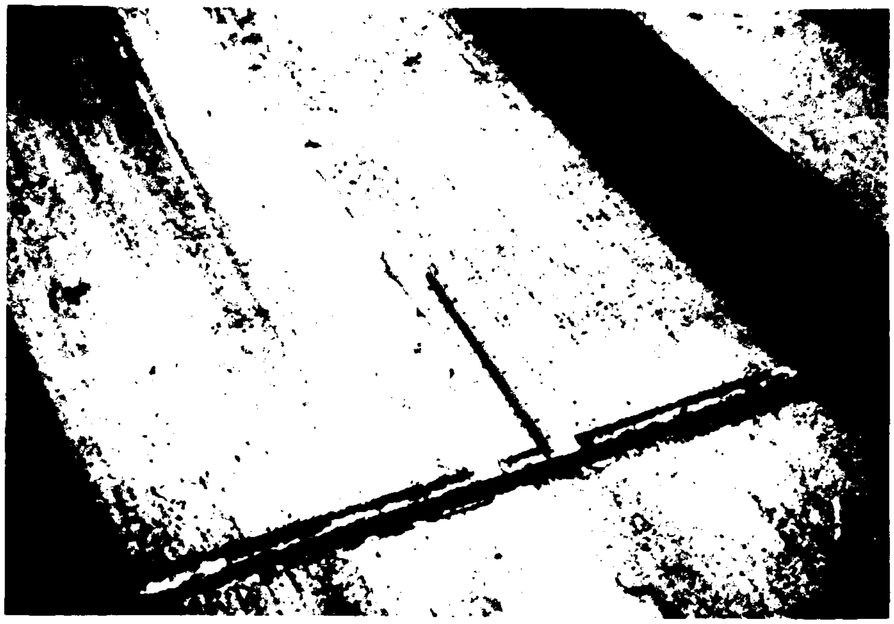

Figure B-126. Shrinkage crack, case 1

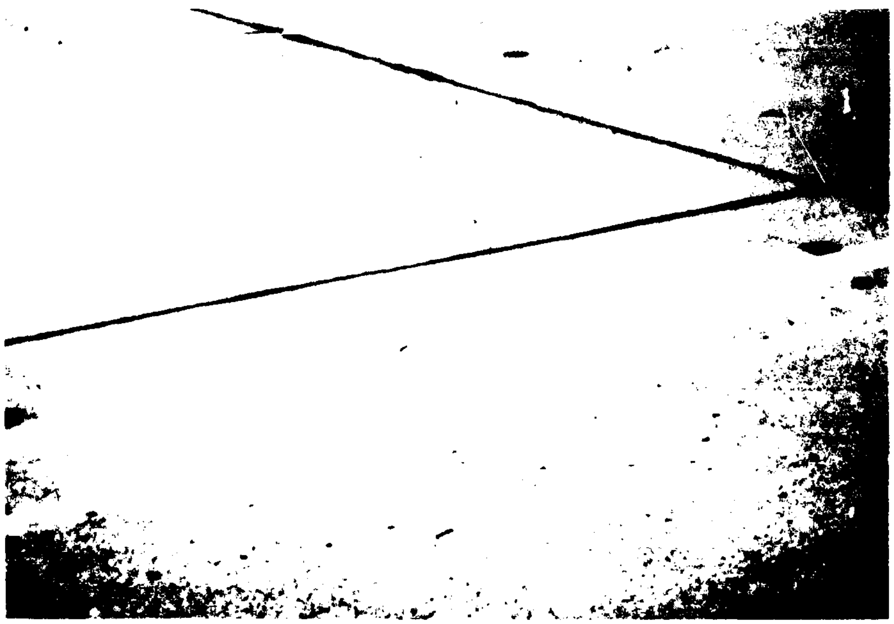

Figure B-127. Shrinkage crack, case 2

Figure B-128. Shrinkage crack, case 3

Counting Procedure. If one or more shrinkage cracks exist on one particular slab, the slab is counted as one slab with shrinkage cracks.

SPALLING (TRANSVERSE AND LONGI-
TUDINAL JOINT) - DISTRESS NO. 14

Description. Joint spalling is the breakdown of the slab edges within 2 ft of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Spalling results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or traffic load. Weak concrete at the joint (caused by overworking) combined with traffic loads is another cause of spalling.

Severity Levels.

a. Low severity level (L).

(1) Spall over 2 ft long:

(a) Spall is broken into no more than three pieces defined by low or medium severity cracks.

(b) Joint is lightly frayed either with little, if any, loose or missing material.

(2) Spall less than 2 ft long is broken into pieces or fragmented with little loose or missing material or tire damage potential (Figures B-129 through B-131).

Figure B-129. Low severity joint spall, case 1

Figure B-130. Low severity joint spalling, case 2 (If the frayed area was less than 2 ft long, it would not be counted.)

Figure B-131. Low severity joint spall, case 3

b. Medium severity level (M).

(1) Spall over 2 ft long:

(a) Spall is broken into more than three pieces defined by light or medium cracks.

(b) Spall is broken into no more than three pieces with one or more of the cracks being severe with some loose or missing material.

(c) Joint is moderately frayed with some loose or missing material.

(2) Spall less than 2 ft long is broken into pieces or fragmented with some of the pieces loose or absent with some tire damage potential (Figures B-132 and B-133).

c. High severity level (H). Spall over 2 ft long:

(1) Spall is broken into more than three pieces defined by one or more high severity cracks with high possibility of the pieces becoming dislodged.

(2) Joint is severely frayed with a large amount of loose or missing particles (Figures B-134 and B-135).

Note: If less than 2 ft of the joint is lightly frayed, the spall should not be counted.

Figure B-132. Medium severity joint spall, case 1

Figure B-133. Medium severity joint spall, case 2

Figure B-134. High severity joint spall, case 1

Figure B-135. High severity joint spall, case 2

Counting Procedure. If the joint spall is located along the edge of one slab, it is counted as one slab with joint spalling. If spalling is located on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling can also occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling.

SPALLING (CORNER) -
DISTRESS NO. 15

Description. Corner spalling is the raveling or breakdown of the slab within approximately 2 ft of the corner. A corner spall differs from a corner break in that the spall usually angles downward to intersect the joint, while a break extends vertically through the slab.

Severity Levels.

a. Low severity level (L). One of the following conditions exists:

(1) Spall is broken into one or two pieces defined by low severity cracks. Pieces are not easily dislodged.

(2) Spall is defined by one medium severity crack with the material secured in place (Figures B-136 and B-137).

Figure B-136. Low severity corner spall, case 1

Figure B-137. Low severity corner spall, case 2

b. Medium severity level (M). One of the following conditions exists:

(1) Spall is broken into two or more pieces defined by medium severity crack(s), and a few small fragments may be absent or loose.

(2) Spall is defined by one severe, fragmented crack that may be accompanied by a few hairline cracks.

(3) Spall has deteriorated to the point where loose material exists (Figures B-138 and B-139).

c. High severity level (H). One of the following conditions exists:

(1) Spall is broken into two or more pieces defined by high severity fragmented crack(s) with loose or absent fragments.

(2) Pieces of the spall have been displaced to the extent that a tire damage hazard exists (Figures B-140 and B-141).

Counting Procedure. If one or more corner spalls having the same severity level are located in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab having the higher severity level.

Figure B-138. Medium severity corner spall, case 1

Figure B-139. Medium severity corner spall, case 2

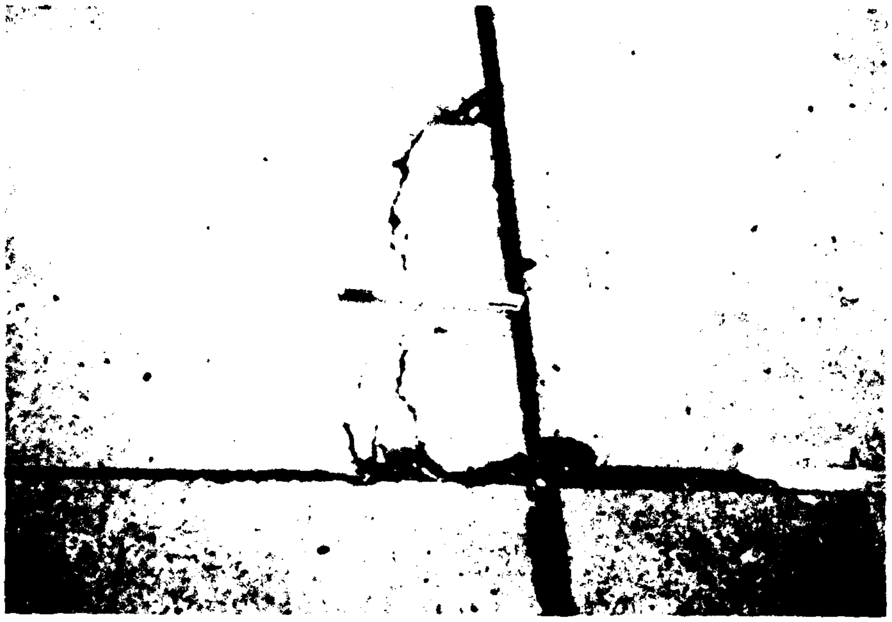

Figure B-140. High severity corner spall, case 1

Figure B-141. High severity corner spall, case 2

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